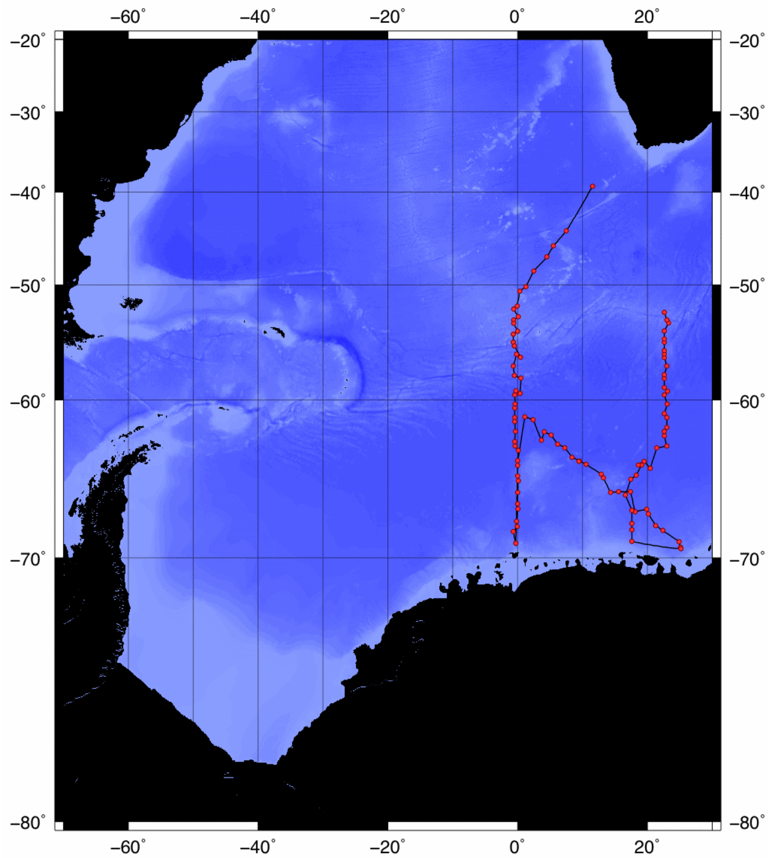
CRUISE REPORT: A12

(Updated JAN 2012)



1. HIGHLIGHTS

CRUISE SUMMARY INFORMATION

WOCE Section Designation	**A12**
Expedition designation (ExpoCodes)	**06AQ200211_2**
Chief Scientists	**Eberhard Fahrbach/AWI**
Dates	2002 NOV 24 - 2003 JAN 23
Ship	*R/V Polarstern*
Ports of call	Cape Town, South Africa
Geographic Boundaries	39° 3.35' S 0° 6.74' W 25° 14.03' E 69° 53.08' S
Stations	100
Floats and drifters deployed	9 RAFOS floats deployed
Moorings deployed or recovered	9 moorings recovered & re-deployed

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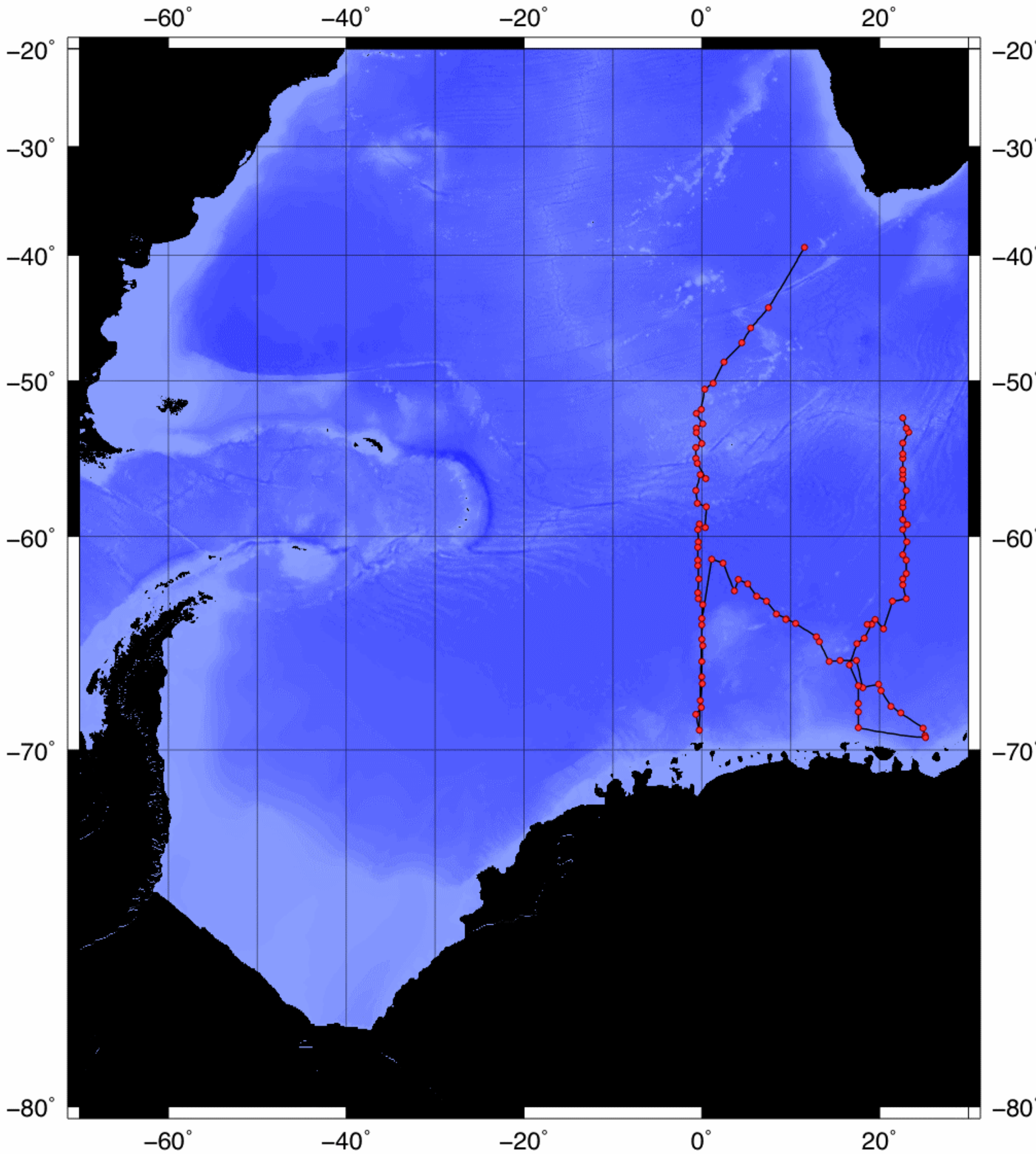
LINKS TO SELECT TOPICS

Shaded sections are not relevant to this cruise or were not available when this report was compiled.

Station Locations • A12_2002 • Fahrbach • *R/V Polarstern*



2. The Expedition ANTARKTIS-XX/2

Cape Town - Cape Town

November 24, 2002 to January 23, 2003

2.1 Summary and Itinerary

Dieter K. Fütterer

The second leg of *RV POLARSTERN* expedition ANT-XX was devoted to a multidisciplinary research programme in the eastern Weddell Sea and Riiser Larsen Sea. It focused on oceanographical, geochemical and sedimentological projects carried out along two transects, from north to south along the Prime Meridian and from south to north along 23° longitude east (Figure 2.1-1). Apart from the scientific programme, the - as early as possible in the season - supply of Neumayer and Kohnen stations and the logistic support of AWI polar aircrafts as well as research projects at Neumayer played an important role on this leg. Its scheduling was done on site absolutely depending on sea-ice conditions.

A major goal of the hydrographic investigations was the recovery (after two years of deployment) and redeployment of nine mooring systems along the Prime Meridian in the framework of the WECCON project (Weddell Sea convection control) which was started already in 1996. This project was complemented by a complete CTD (conductivity, temperature, depth) and water sampling programme along the Prime Meridian and along 23° longitude east for Carbon dioxide investigations, CFC tracers, naturally radionuclide tracers and chlorophyll and particle flux investigations as well as for a small biological project dealing with virioplankton and oligotrophic bacteria.

The marine geological investigations concentrated mainly to sediment coring and sampling of a channel-levee system on the continental slope of the southern Riiser Larsen Sea (see GeoBox in Figure 2.1-1). Swath sonar bathymetric measurements with the Hydrosweep system planned to contribute to the AWI Bathymetric Chart of the Weddell Sea (BCWS) and subbottom echosounding profiling with the Parasound system in support of the sedimentological project were only partially successful due to very specific obligations by the German Federal Office for the Environment (UBA) for operating all hydro acoustic devices, e.g. echosounding systems. However, extensive experience was gathered on the efforts and needs to run a permanent passive acoustic and visual monitoring of marine mammals while doing acoustic profiling (see Chapter 2.4).

RV POLARSTERN set sail in the evening of November 24, 2002 with an international team of 51 scientists and technicians from seven countries, PR China, Germany, Greece, Mexico, The Netherlands, South Africa, United Kingdom, and 43 crew and left the harbour of Cape Town (South Africa) on a south westerly course heading for the Prime Meridian at 51 degree latitude south (Figure 2.1-1).

Fine weather and calm sea conditions during the first days of the cruise enabled *POLARSTERN* to make good progress. After leaving the South African EEZ, a continuous en-route bathymetric and acoustic sediment profiling survey was started using the ship's swath sounding Hydrosweep system and the Parasound system, respectively. On November 26, a test station for the CTD/rosette system at 39°33'S, 11°05'E and a towing test at different speed of the hydrophone streamer system for acoustic mammals monitoring were carried out successfully.

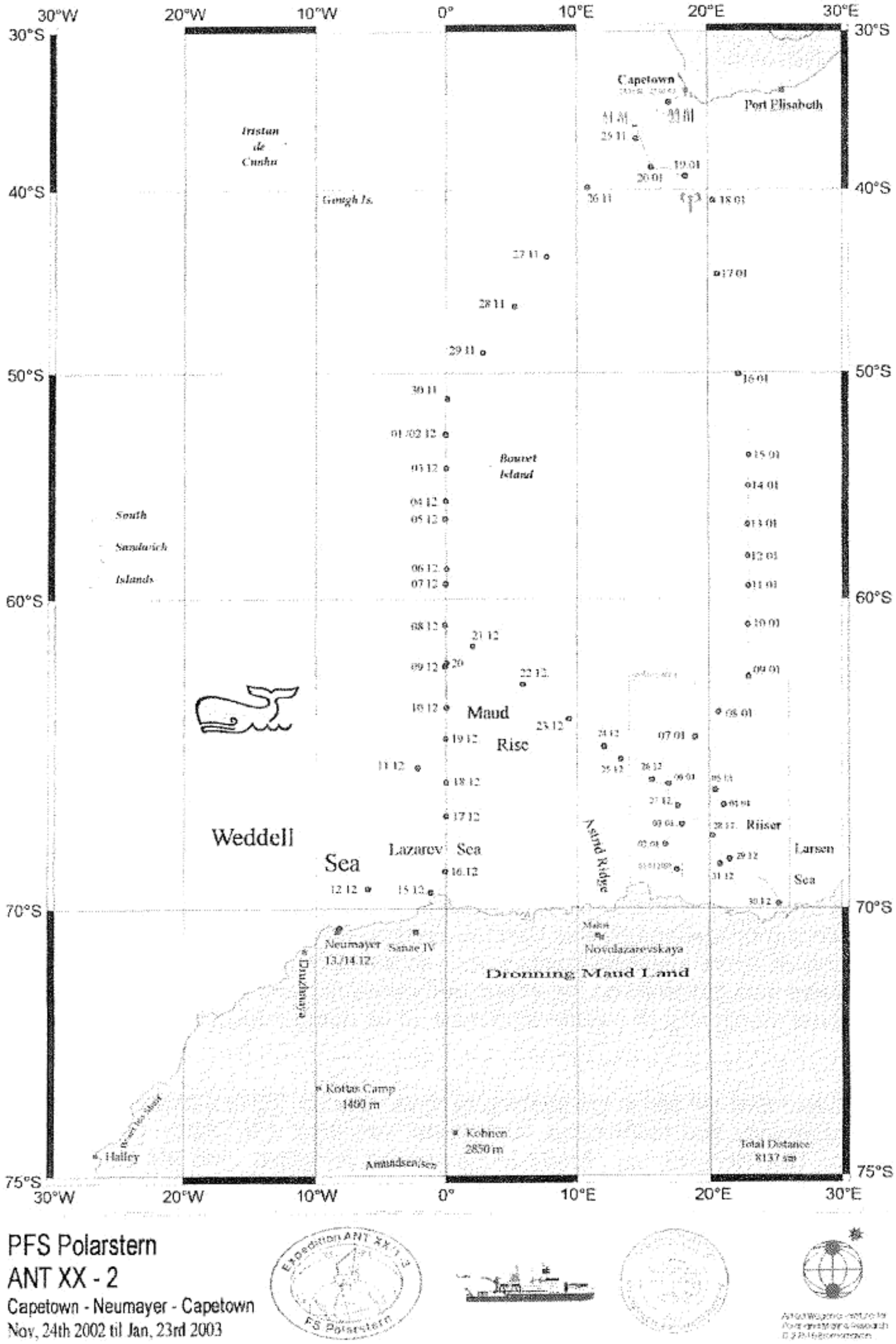


Figure 2.1-1: *Cruise track of RV POLARSTERN during ANT-XX/2*

Regular hydrographic station work started on November 27, along the TOPEX / POSEIDON ground track #133 along which two pressure inverted echosounders (PIES) were deployed. At regular distance of about 70 nautical miles a CTD (Conductivity, Temperature, Depth) sonde and attached rosette water sampler were used to provide the various projects with hydrographic data and water samples. Strong gale during these days, lasting until December 04, caused difficult working conditions. Two CTD stations had to be cancelled because of heavy sea state.

The Prime Meridian was reached on November 30, to continue CTD and rosette sampling at regular distances of half degree latitude or 30 nautical miles from 50°S to 69°S as part of the WECCON (Weddell Sea Convection Control) project. As a major component of WECCON, nine mooring systems deployed two years ago along the Prime Meridian were to be recovered and redeployed. The first mooring system was recovered under extremely difficult sea state conditions on December 01. The first attempt to deploy the new system had to be stopped. It was successfully deployed only later the next day when sea state conditions had improved slightly.

First icebergs were sighted in the morning of December 04, and the ice edge consisting of dense but loosely packed drift-ice was met unexpectedly far north, at about 56°30'S during the afternoon of the same day. Ice coverage intensified and increased from 5-7 tenths to 8-9 tenths while CTD station work progressively moved south. Wind force decreased, and together with moderately strong coverage of relatively soft and thin one-year ice, working conditions changed considerably to the better.

On December 07, crossing 60° south latitude, *POLARSTERN* entered the area under the Antarctic Treaty legislation. To perform the special requirements laid down by the German Federal Office of the Environment (UBA) for operating the swath sonar Hydrosweep and sediment echosounder Parasound systems and all other hydroacoustic devices scientists set up a passive acoustic as well as a visual monitoring of marine mammals. Once marine mammals, seals or whales, were sighted or recorded, the ship's sonar systems (Hydrosweep swath sounder and Parasound subbottom echosounder) had to be shut down for a certain period and reactivated only if no other mammal had been sighted meanwhile. Especially the visual monitoring increased the general watch keeping duties for all scientists tremendously.

CTD station work was continued until December 10, at 64°S, west of Maud Rise where a mooring system was recovered and deployed before *POLARSTERN* at almost midnight shaped course for Atka Bay and Neumayer Station. Very convenient ice conditions, 4/10 of ice coverage and wide open water made good headway. Ice conditions changed to the worse during December 11, when thick flows of strongly ridged multi-year ice with a thick snow cover became more and more predominant. Tough ice conditions prevailed until the next morning when the dense pack ice opened slowly and *POLARSTERN* reached the wide open coastal polynya stretching from 5°W to 15°W (see Figure 2.3-la).

Late in the evening of December 12. *POLARSTERN* arrived at Atka Iceport which - according with the early season - was completely covered by a complete and intact ice cover. By midnight the ship came alongside the exposed "Nordanleger" in the lee of a huge grounded iceberg where the ice-edge reaches a height of approximately 12 m. Cargo operations started early in the morning of December 13, and - meeting fine weather conditions - were finished in the late afternoon of December 14. While the vessel stayed at the "Nordanleger" satellite transmitters were mounted during helicopter flights on three suitable icebergs for tracking them during melting Supported by helicopter, two hydroacoustic experiments to record seal songs from open leads in the sea ice cover of Atka Bay were carried out as well. Other scientists and crew that had riot visited Neumayer Station before took the chance of a helicopter shuttle to the station.

Late in the evening of December 14, *POLARSTERN* left Atka Bay and steamed through the widely open waters of the polynya on northeasterly course along the ice edge for the Prime Meridian at about 69°S, slightly north of Trolltunga. Shortly before midnight *POLARSTERN* met with the Russian research vessel *ACADEMIC FEDOROV* which passed nearby on her way for Neumayer Station. Between December 15 and 20 intensive CTD station work and sediment sampling along the Prime Meridian from 69°20'S to 64°S in the western Lazarev Sea was carried out. Additionally, four mooring systems were recovered and deployed and a 19 m long piston core was recovered at 61°S. Improving ice conditions changed from heavy pack and 8-10 tenths coverage in the south to almost open water in the north, and made station work increasingly easier. By means of a number of helicopter flights four icebergs between 69°S and 64°S were marked by satellite transmitters.

From December 21 through December 26 a transect of hydrographic CTD stations and geological multi-corer stations was sampled at regular distances of 38 nautical miles each, from the Prime Meridian at 61°S, north of Maud Rise, to 66°26'S, 15°55'E east of the Astrid Ridge in the western Riiser Larsen Sea. A sound-source mooring was deployed at 64°31'S, 09°50'E and at 64°53'S, 10°57'E use of the in-situ pump system was made for sampling large volume samples for natural radionuclide tracers. Regular sampling was interrupted from December 24 to 25 to celebrate the Christmas Eve.

From December 26 to January 06 Hydrosweep bathymetric swath sonar profiling for areal mapping of erosional channels and Parasound sediment profiling for mapping the thickness of the sedimentary cover and identifying suitable sediment coring sites were carried out in parallel with sediment sampling by gravity corer and multi-corer (MUC) in the so called GeoBox in the southern Riiser Larsen Sea. Regular CTD station work was continued to extend the hydrographic transect started at the Prime Meridian to the southeast as far as to 69°55'S, 25°30'E near the ice shelf edge of the Prinsesse Ragnhild Kyst. There, ice surveys by helicopter along the shelf ice edge revealed 8-9 tenths coverage of thick multi-year ice extending far to the west in the direction for the Astrid Ridge. Therefore, it was decided on December 30, not to take direct course to Erskinebukta in the west but to choose a more northerly course where thinner one-year ice eased the ice conditions, as experienced the days before. The New Year's Eve was celebrated while transiting from the eastern to the western part of Riiser Larsen Sea.

On January 02, 2003 an acoustic experiment to record and distinguish sounds of marine mammals, e.g. seals, without the strong background noise of *RV POLARSTERN* was carried out using one of *POLARSTERN*'s life boats in the drift-ice zone of the northern Riiser Larsen Sea. Sediment profiling in the GeoBox in general but specifically in the densely ice covered area of the southern Riiser Larsen Sea near the shelf ice edge was severely hampered by complying with the specific environmental restrictions of the German Federal Environmental Office (UBA) for the use of active acoustical devices.

From January 07 through the afternoon of January 15 intensive hydrographic as well geoscientific sampling was carried out along 23° east longitude. CTD/rosette and fluorometer casts were taken regularly each half degree latitude or 30 nm in distance, Long piston cores and surface samples by multi-corer were taken on selected sites at 60 to 90 nm distance, precise locations identified from existing Hydrosweep and Parasound records or from online surveys where available according to environmental injunctions. Station work was generally favoured by calm weather conditions. However, piston coring in greater water depths, deeper than 5000 m, was substantially hampered by high swell during January 10 to 12. Hydrosweep swath sounding and Parasound sediment profiling was carried out continuously north of 60°S.

An exceptional event occurred on January 15 when during station work for several hours altogether more than 20 Humpback whales played around the vessel showing not dread of the vessel itself and of ongoing sampling activities or of active sonar systems.

During the night from January 15 to January 16 the hydrographic transect along 23°E was finished at 53°S In the same night a large low pressure system caused fresh gale and heavy sea preventing *POLARSTERN* from further piston coring. A fundamental decision was required how to spend the remaining station time of the cruise, to wait on site for increasing weather conditions to proceed with piston coring along 23°E or to escape as fast as possible to the north to sample the Agulhas system around 40°S with CTD and *in-situ* pumps for a hydrographical-geochemical project and to sample additional piston cores *en route* where feasible. *POLARSTERN* left the area around 52°S and sailed north assisted by strong southerly winds and swell astern.

During daytime of January l8 to January 2l the waters of the Agulhas Retroflection and associated gyre system of the Agulhas Rings at 40 to 36°S and 20 to 14°E were sampled on four long-lasting stations by *in-situ* pumps and CTD while night-time was used for transit between stations. Refreshing winds and swell and strong currents during January 19 caused difficult working conditions on station, cancellation of CTD casts and delayed beginning of station work on January 20. Bright sunshine and calm sea saw the final station work of this cruise when the last CTD came on board in the late afternoon of January 21, After 60 days at sea and a distance of about 8100 nautical miles, *RV POLARSTERN* arrived on schedule in Cape Town in the early morning of January 23, 2003.

2.2 Weather conditions during ANT-XX/2

Hans-Arnold Pols

Shortly after leaving Cape Town *RV POLARSTERN* encountered a narrow line of strong winds reaching gale force; caused by a pressure gradient between the South Atlantic subtropical high and a small low off the coast of Namibia. During the first night at sea. wind increased up to force 9 Bft. On November 26, following a calm passage of the subtropical high, the ship entered the zone of westerly winds between 40 and 60°S. From that time on it was affected on several occasions by intense depressions, rapidly moving eastward in the zonal flow.

On November 30 *POLARSTERN* reached the Greenwich Meridian. On that day a cyclone, with a pressure of 960 hPa at its centre, crossed the vessel's course. At the back of this low the wind increased up to force 10 to 11 Bft, with gusts of force 12 Bft. The wind remained at force 8 for several days after the passage of this storm, with continued westerly cyclonic flow. On December 03 another intense low pressure system passed the ship. Near the centre of that low a measurement of 945 hPa was recorded. This proved to be the lowest pressure reading of the cruise. However, the wind at force 9 Bft did not reach the same intensity as before. When this depression moved eastward, a region with weak pressure gradients was entered. In this region the ship was affected by winds with mean values of force 5 Bft, and the swell reduced proportionally.

On December 04 *POLARSTERN* reached the sea-ice edge off the Antarctic coast. The sea ice considerably damped the swell. In the following weeks the ship faced continuous pack-ice conditions. These were coped with successfully. Intensive depressions, moving on a Northerly path, were met but these did not affect the work on *POLARSTERN*. Wind speed reached force 6 to 7 Bft for some periods.

In mid December, the Neumayer-Station was supplied under a weak high pressure influence and nearly moderate winds. The following week *POLARSTERN* headed back northwards following the Prime

Meridian. Between a ridge of high pressure, reaching from the South Atlantic to the Weddell Sea, and a westward moving depression at the Riiser Larsen Sea, wind increased up to force 8 Bft. on December 21. The ship then found open water in a polynya close to 62°S.

Altering course to south east for the Riiser Larsen Sea, and making for the GeoBox working area, a ridge of high pressure crossed the route. Weak pressure differences then prevailed until the beginning of January. In the first week of the New Year, air pressure varied only 8 hPa between low and high. During that time wind only rarely reached force 6 Bft. The easterly flow prevailed with force 4 to 5 Bft. during Christmas and from January 4 to 6 calm conditions was observed with the sea as smooth as a mirror. This coincided with periods of low ceiling and poor visibility, occasionally accompanied by fog and snowfall. Dense multi-year sea-ice made work more difficult on reaching Prinsesse Ragnhild Kyst.

By January 10, 2003 *RV POLARSTERN* had reached 63.5°S, 23.5°E. Now in open water and heading northwards again, the course was affected by a low which then developed into a dominating feature. About evening the wind had increased up to force 8 to 9 Bft. with associated wave-heights of 4-5 m. For the next few days, and into the third week of January, the ship stayed near to the centre of that low. Although wind strengths decreased, wave heights of 4 m were still prevalent.

On January 15 an intense low developed from a wave disturbance and passed to the north of the ships cruise. Wind increased from force 2 Bft, at noon to force 9 to 10 Bft, by midnight. The south-westerly storm lasted until the evening of the following day. Later, the wind decreased a little, due to a weak ridge of high pressure, but another intense depression then approached from the west.

For the rest of its continuing cruise to the north *RV POLARSTERN* met stormy northerly winds. The cold-front of a low was trailing in the north and several wave disturbances developed. The low's influence extended up to the latitude of 35°S. Ahead of the front, on January 18 north-westerly winds of force 8 Bft., with gusts reaching gale force, were observed. After the passage of the front, *RV POLARSTERN* entered the trough of the same intense low. Here the ship was affected by wind speeds of force 9 to 10 Bft., and with gusts up to force 12. Wave heights of 8 m and more were encountered, with very short wave-periods. During January 20 these conditions improved only slowly. However, bright sunshine and calm sea prevailed during station work the following days and on arrival in Cape Town in the morning of January 23, 2003.

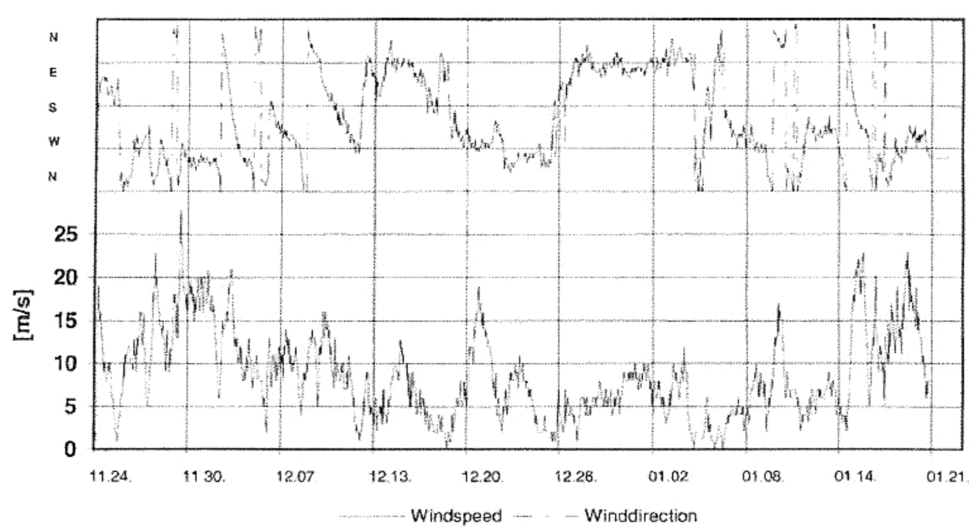


Figure 2.2-1: *Time series of wind speed and directions during RV POLARSTERN cruise ANT-XX/2.*

2.3 Ship-based observation of sea ice thickness and characteristics

Olaf Klatt, lsmael Nunes, Sandy J. Thomalla and Sebastian Wahl

The sea-ice thickness distribution is a fundamental parameter for defining the extent of ocean-atmosphere interaction within the sea ice zone. It cannot be measured remotely; hence the need for *in situ* measurements to determine the distribution and thickness of different ice types within the pack ice zone. As a contribution to the to the multidisciplinary Antarctic sea ice zone research project ASPeCt (Antarctic Sea ice Processes and Climate) a standard set of observations were made almost hourly from the bridge of *RV POLARSTERN*. These include the ship's position and an estimate of the aerial ice coverage, thickness, floe size, topography and snow cover of the three dominant ice thickness categories within a radius of approximately 0.5 nautical miles of the ship. The ice thickness classification is shown in Table 2.3-1. Furthermore, the meteorological conditions such as air and water temperature, wind speed and direction, cloud cover and visibility were recorded at every observation. The entire data set, which consists of about 300 single observations, is submitted to ASPeCt.

Table 2.3-1: *Ice thickness classifications used for the ship-based observations*

Ice Type Classification		Ice Thickness (m)
new ice	Frazil Shuga Grease Nilas	<0.1
pancakes		no defined range
young grey ice		0.10-0.15
young grey-white ice		0.15-0.3
first year ice		0.3-0.7
first year ice		0.7-1.2
first year ice		>1.2
multi-year ice		<10
brash		no defined range
fast ice		<2

At noon on December 4, 2002 *RV POLARSTERN* reached the ice edge at 56.5°S and 0.0°E. Satellite images showed, at this time almost the whole Weddell Sea was covered with ice (Figure 2.3-la), but two areas of low ice concentrations (polynyas) can be identified at the cruise track. The first is located at the Prime Meridian (64°S), the second at about 10°W 70°S close to the shelf ice off Ekström Ice Shelf. During December the ice has vanished over almost the entire area of investigation and only an ice field at about 10°E in front of the Riiser Larsen Ice Shelf is visible (Figure 2.3-1b).

As an example of ship-based observations, the aerial ice coverage and thickness for the Prime Meridian is shown in Figure 2.3-2. At the northern end of the Prime Meridian (56- to 62°S) the mean total ice coverage was roughly 60%. The dominant ice type was first year ice with a thickness of around 50 cm. Both the ice coverage and thickness between 62-64°S were very low and the polynya could be identified

(Figure 2.3-1). South of 67°S the first year ice became denser with up to 90% aerial coverage and increased in thickness to 150 cm. *RV POLARSTERN* left the ice on the afternoon of the January 3, 2003.

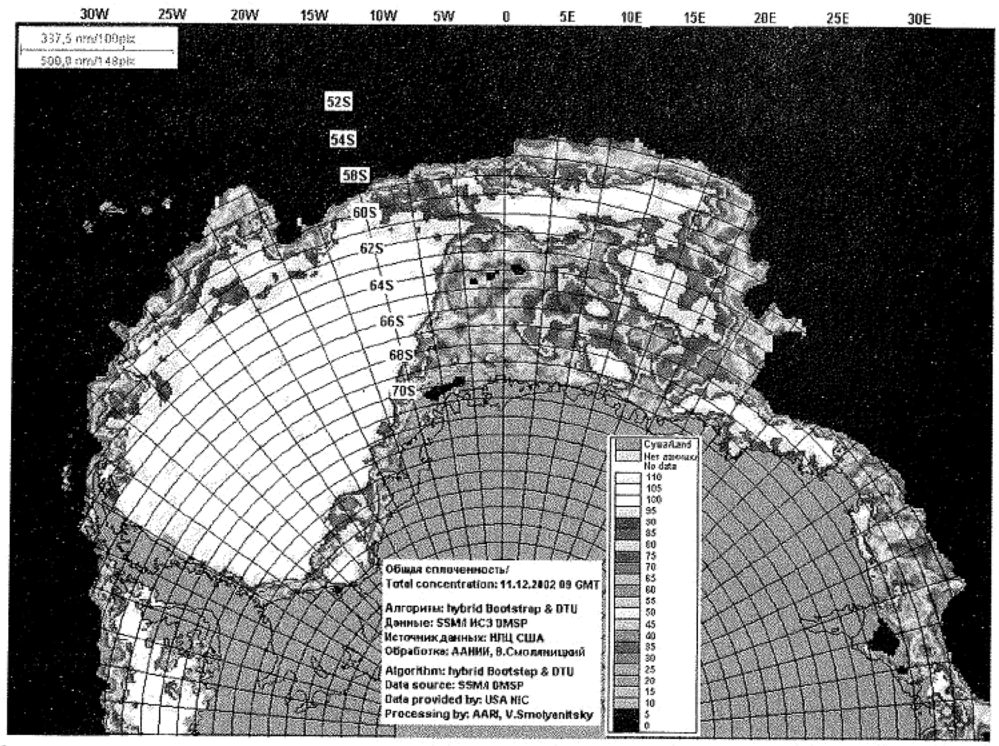


Fig. 2.3-1a

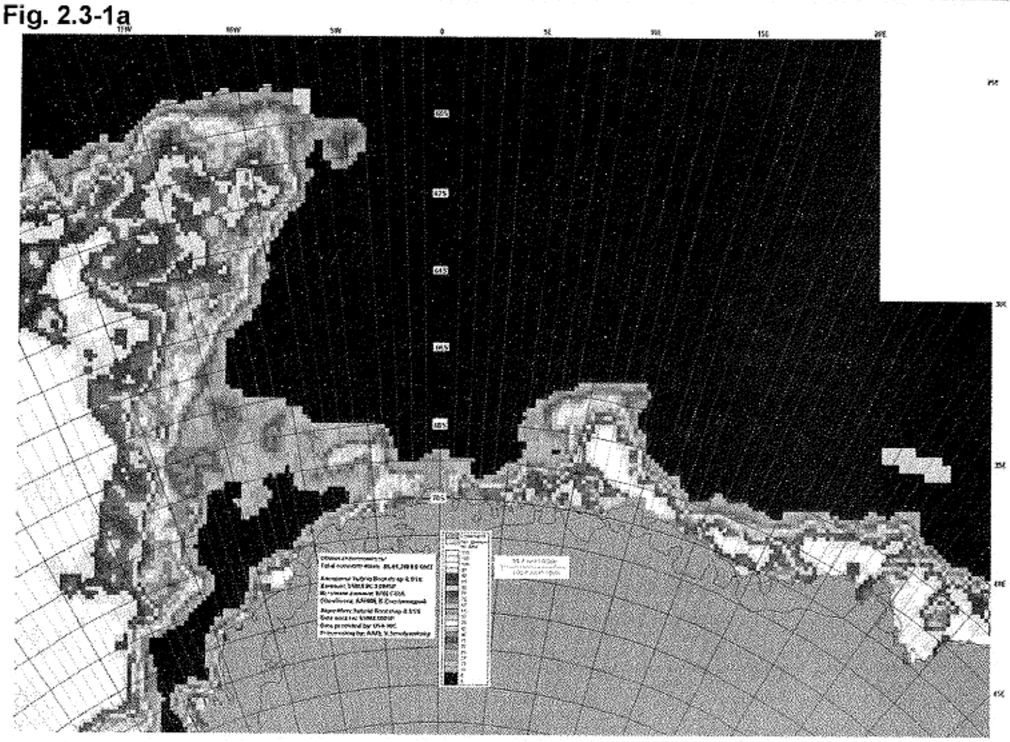


Fig. 2.3-1b

Figure 2.3-1: *Total ice concentration of the Weddell Sea at (a) December 11, 2002 and (b) January 6, 2003*

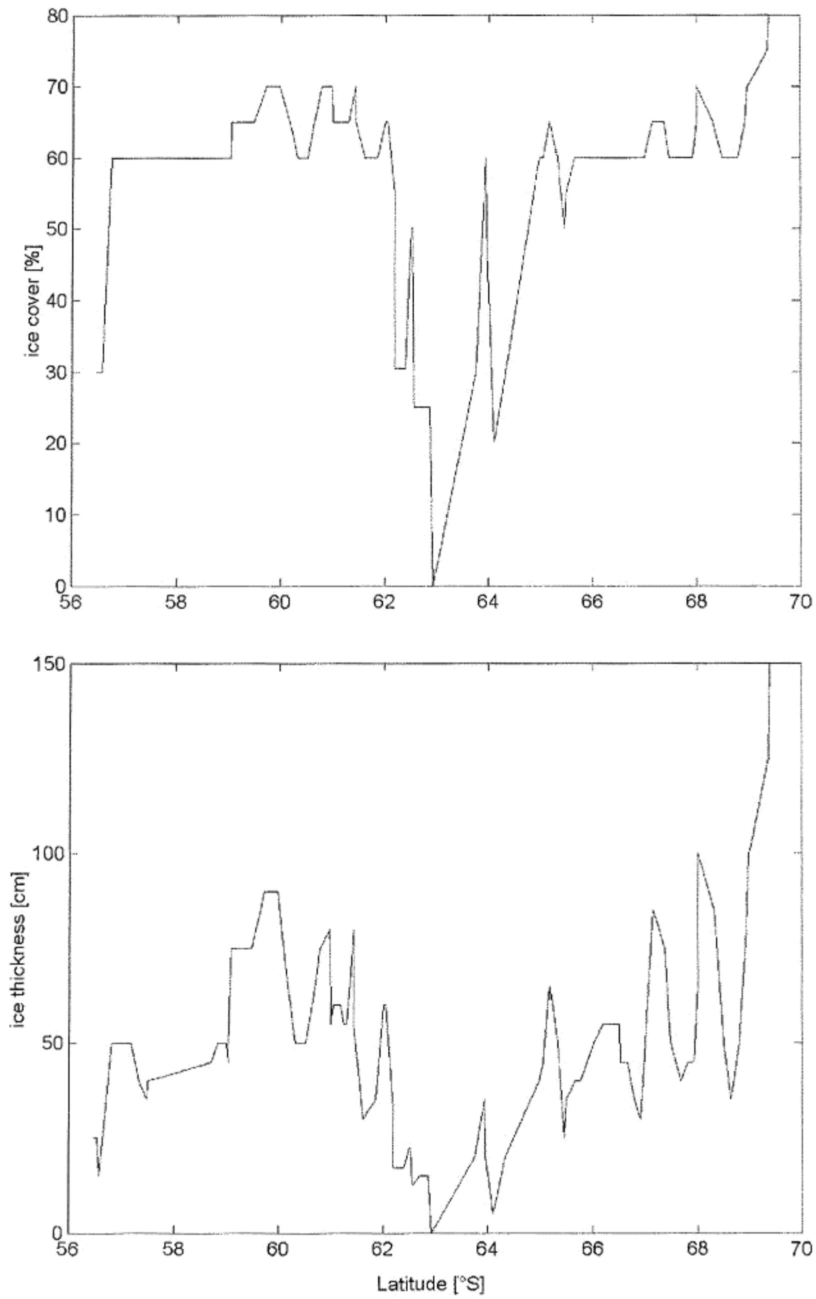


Figure 2.3-2: *Ice cover (a) and thickness of ship-based observations at the Prime Meridian*

2.4 Observation and identification of marine mammals

Wolfgang Dinter and Gerd Kuhn

The obligations for marine mammal monitoring and observation as a mitigation measure related to the permissions for high powered acoustic devices as Hydrosweep and Parasound during *POLARSTERN* research cruise ANT-XX/2 provided the rare possibility to get a widely full-time survey of marine mammals along the ship's track as a byproduct.

The spotting rate is believed to be quite high due to the high deployment of manpower even though most observers were initially not experienced in this task. This resulted in a relatively high number of spottings where species initially were not identified but it gave an overlook about abundance and distribution patterns.

The visual survey width depended strongly on visibility/visible range (sea state, weather conditions, ice-cover, ridges on ice-floes) and heights of platform but was generally good for identification up to a radius of 500 m around the ship and decreased with distance due to the factors mentioned.

Observations began already on November 27, 2002 at 43°37'S 7°60'E for training purposes while steaming SW towards the Prime Meridian transect, although it was obligatory only for the Antarctic Treaty Area south of 60°S which was reached on late December 7. After leaving the Antarctic Treaty Area on January 11, 2003 observations were made only occasionally until reaching Cape Town on January 23, 2003.

Additional marine mammal records could be made from >600 nm surveys on six helicopter flights in the region between 67-70°13'S and 14°56'-25°14'E.

Methods

Observation was done by scientists and technicians (mainly oceanographers, geologists, and geochemists) besides their other regular duties and work programmes. Each observation turn lasted in general no longer than two hours, to avoid fatigue of observers. Position of the observers was generally on the bridge, ~19 m plus eye's heights above water level, and voluntarily in some cases for one observer on the crows nest, ~28 m plus eye's heights above water level. Numerous binoculars (Steiner 7 x 50) for distant observation were available throughout the bridge area.

Initially, marine mammal watch-keeping was conducted with three observers, but according to a change in the observing obligations, after December 21, 14:00 UTC, general observation was made by two observers during transit and by one observer while on station.

Observation was cancelled during hours of darkness in more northerly latitudes and on very long stations, where the acoustic devices were shut down. Observation was also cancelled or took place only with a reduced personnel of one observer during times when the acoustic device were shut down on some transit transects due to too many mammals and/or already known sea bottom structure and at times where it was intended to avoid the streamer to be damaged in too heavy ice.

Assessment of the observation effort

Generally it was obvious that the detection rate and observation quality is depending on:

A) physical optic:
- visibility or visible range (sea state, weather conditions, ice-cover, ridges on ice-floes),
- height of platform (seals rested frequently behind ridges on ice floes / whales in wavy seas → detectable from the crows nest but sometimes not from the bridge;
- state of windows of bridge and crows nest: in open water frequently covered by spray and salt,

B) observers:
- motivation (such as personal interest or conflict of interests),
- experience,
  → detection rate,
  → behavioural documentation,
  → behavioural assessment,
  → contrary interpretations;
- individual visual ability (e.g. short-sighted vision),
- number of observers.

Evaluation of the sightings in relation to distribution and behaviour

Although there were regions without any marine mammal sightings along the ship's track it was obviously, that there are patterns of abundance and distribution clearly correlated with patterns of ice-cover and therefore with the seasonal variation. General Antarctic marine mammal abundance and distribution patterns could be confirmed for the surveyed area through this intense observation.

Most whales enter Antarctic waters with the seasonal breaking up of the pack-ice and further melting of the drift-ice and thus are found in higher numbers at ice-edges and along fringes of open water areas even though some whales are reported to over-winter at polynyas and leads.

There are only few records of young or juvenile whales in Antarctica. Therefore, it was surprising to spot one juvenile humpback whale (Megaptera novaeangliae) together with two adults already on December 3 at 54°01.5'S, 0°06.7'W relatively close to the northern ice-edge.

Whales (Minke, Humpback) approached *R/V POLARSTERN* exclusively only on station but all sighted species showed a behaviour range from being unaffected over avoidance to flight responses during transit cruise of the ship. This corresponds well with the general behaviour of Minke whales described at Richardson et al. (1995, p: 272 and references therein). Flight responses could not be related to the use of the different hydroacoustic systems because these were immediately shut down with any spotting. Those Minke whales that approached the ship could clearly be identified as belonging to the southern species Antarctic minke whale (*Balaenoptera bonaerensis*).

Even though there were spotted many Minke whales or "like Minke whales" alone (Table 2.4-1), the mean sighting number was 2.44 whales per sighting

Weddell seals *(Leptonychotes woddellii)* were most numerous in colony-like assemblages on fast ice and pack-ice along coastal polynyas. Leopard seals *(Hydrurga leptonyx*) appeared to be mostly at the outer ice-edge or at the fringe of coastal polynyas and larger open water patches while Ross seals *(Ommatophoca rossii)* were seen in areas of denser ice-cover. Crabeater seals *(Lobodon carcinophagus)* were spread throughout the entire ice-belt and were as well as the two species mentioned last mostly encountered alone (mean sighting rate of all seal species 1.36) and resting/sleeping behind ice-ridges. All seals of all species resting on ice reacted to the ship passing by either by no reactions at all or by waking up and sometimes associated with a threatening gesture (raising head and open mouth) or by a short flight response on the ice. Short range (2-7 m) flight response was nearly exclusively on ice and from 358 shipboard sightings only three times into the water. On the other hand a few (three) seals fled out of the water onto ice-floes in the immediate vicinity of the ship when it approached. The assumption related to this behaviour is that Antarctic seals during evolution never had terrestrial (on ice) predators but in the water in contrast to all northerly seals that typically flee into the water due to their main enemies (humans, polar bears) on land (on ice).

Reference

Richardson, W.J., Greene, C.R., Malme, C.J. & Thomson, D.H. (1995): Marine Mammals and Noise.- Academic Press, San Diego.

Table 2.4-1: Summary of marine mammals observations.

Shipboard sightings

Watchkeeping. 27.11.02 10:00 - 10.01.03. 15:40; 333 sightings from shipboard, it was always counted the higher number when not indicated exactly; (d = definitely, pr = probably, po = possibly

	Unidentified whales	like Minke whales (pr, po)	Minke Whales (d)	Southern Bottlenose whales (d, pr, pa)	Arnoux's Beaked whales (d, pr, po)	Humpback Whales (d pr, po)	Unidentified seals	Crabeater Seals (d, pr, po)	Weddell Seals (d,pr,po)	Ross Seals (d, pr, po)	Leopard Seals (d, pr, po)
on ice							124	194	23	7	3
in water	25	59	56	13	7	9	2	2	1		
							128	196	24		
	171						358				
529											

171 Whales in 70 sightings (171/70, average 2.44);
358 Seals in 263 sightings (358/263, average 136);
529 Marine Mammals sighted from shipboard (529/333, average 159)

Sightings on 6 helicopter transectflights/triangular courses

Flight	Minke whales (d)	unidentified seals	Crabeater seals (d, pr, po)	Weddell seals (d, pr, po)	Ross seals (d, pr, po)	Leopard seals (d, pr, po)	lengths of survey flight	waypoints	
27.12.02 ice-survey		13	1	1		1	134,04 nm	67°18'S 68°18,84'S 67°18,73'S 67°19,96'S	14°59'E 14°56,6'E 14°52,03'E 15°25,75'E
28.12.02 snow samples	6	3			1		109,01 nm	68°01,79'S 68°61,56'S 68°35,61'S 68°54,47'S 68°11,31'S	20°34,53'E 20°56,44'E 21°28,32'E 21°54,68'E 21°18,17'E
29.12.02 snow samples		43	7	1	2		117,24 nm	68°50,75'S 69°10,38'S 69°30,85'S 69°50,72'S 68°53,58'S	22°26,8'E 22°27,43'E 22°26,5'E 22°29,45'E 22°39,17'E
30.12.02 acoustic sample at coastal polynya		22	63	29	1	1	~120 nm	69°53,19'S 70°00,91'S 70°12,15'S 69°53,2'S	25°13,62'E 25°01,20'E 24°03,87'E 25°13,62'E
31.12.02 snow samples	32	26		1			68,12 nm	68°53,9'S 68°44,09'S 68°33,43'S 68°15,19'S 68°50,75'S	21°30,74'E 20°42,9'E 21°33,68'E 21°34,99'E 21°9,72'E
02.01.03 snow samples	1	2	6			1	53,21 nm	68°34,1'S 68°35,22'S 68°35,53'S 68°11,84'S 68°18,18'S	17°12,88'E 17°10,98'E 16°17,8'E 16°42,75'E 16°44,27'E
	7	115	103	30	6	3			
	7	257							
	264								

Overall helicopter survey length: ~602 nm = 1115 km; Effective flight survey width = ± survey width from shipboard due to flight velocity

Conclusions

The high number of recorded seals from helicopter is related to the area but even more to the heights of the platform, where many seals behind ice-ridges might not be detectable from shipboard. The habitat relevance for Weddell seals and the general biological importance of the coastal polynya was evident. The low number of whales was most probably due to the early season and to the related dense ice-cover at this region.

Overall marine mammal sightings during ANT XX-2

	Unidentified whales	Like Minke whales (pr, po)	Minke Whales (d)	Southern Bottlenose whales (d, pr, po)	Amoux's Beaked whales (d, pr, po)	Humpback Whales (d pr, po)	Unidentified seals	Crabeater Seals (d, pr, po)	Weddell Seals (d,pr,po)	Ross Seals (d, pr, po)	Leopard Seals (d, pr, po)
sightings from shipboard on ice							124	194	23	7	3
sightings from shipboard in water	25	59	56	13	7	9	2	2	1		
							128	196	24		
	171						358				
6 sighting events from shipboard after 10.01.03						~42					
	213						358				
6 helicopter surveys		7					115	103	30	6	3
		220					615				
overall sighted marine mammals		835									
animals approaching the ship on station 27.11.02-10.01.03		11/7				3/1	1/1	2/2	1/1		
animals approaching the ship on station after 10.01.03						34/3					

2.5 MAX-DOAS measurements of atmospheric trace gases for SCIAMACHY ground truth

Magdalirii Halasi

On *RV POLARSTERN* cruise ANT-XX/2, as also on the cruises Ant-XX/1 and /3, Heidelberg University runs a MAX-DOAS measurement programme. The main objective of these measurements is the identification and concentration of minor gases such as BrO, SO_2, HCHO, H_2O, JO, O_3, NO_2, OClO, O_4 and others.

The South Polar Region and the Atlantic are areas of rare atmospheric measurements. That is why the measurements take place in the whole cruise of *RV POLARSTERN*. A very important fact of the measurement is the validation of the SCIAMACHY-instrument on the European ENVESAT satellite which started during March 2002. One can use the satellite's information only by comparing with real measured values. During 1990, 1993 and 2001/2 similar measurements were done with great success The method used for the detection of the different gases is the DOAS (differential optical absorption spectroscopy). This method makes it possible to measure different tropospheric gases in the different heights.

On this cruise, due to the fact that there was a big oceanographic activity, the measurements were concentrated to a relatively small region. For this experiment this fact is a pity but due to the fact that this area is of so rare atmospheric observation, the data are of great worth.

2.6 Marine sources of reactive organo-iodines and bromines

David Wevill

The aim of this project was to investigate the sources of reactive halogen radicals such as 0 and BrO. Air monitoring was carried out using an automated Perkin Elmer Turbomass GC-MS, The sampling interval was -70 mins and the instrument was running 24 h a day excluding blanks and calibrations. Of the thirteen species monitored (species include CH_3l, $CHBr_3$, CH_2Cll and CH_21_2) only nine were detected so far and will be measuring for the next leg of the cruise. The species not detected were the very short-lived compounds which last only 5-20 mins at noon. A few water samples were also taken from 50, 20 and 11 m (the former pair from CTD and the latter from the seawater pump on board). The results obtained need further scrutiny due the possible presence of algae in the Millipure water used for blanks.

Later it is hoped that a combination of our data with ocean colour information from the SeaWIFFs satellite as well as sea / air temperature can help to determine the role of the open ocean as a source or sink for the compounds of interest.

Continuous CO measurements were also taken during the cruise with an Aerolaser instrument and showed the expected drop in concentration once we had moved below the polar circle. Bottle samples were also taken each day around noon UTC on the transit to Neumayer for post analysis of non-methane hydrocarbons.

2.7 Carbon dioxide investigations in the Antarctic Circumpolar Current and eastern Weddell Gyre

Mario Hoppema and Dorothee C.E. Bakker

Modifications of the global carbon cycle, by the burning of fossil fuel and changes in land use, have led to an increase in atmospheric carbon dioxide (CO_2) which has the potential to increase the greenhouse effect of the atmosphere, in turn leading to increased global temperature. The deep oceans are, in principle, able to take up almost all of this excess CO_2, but only on a time scale which is much longer than the one associated with the anthropogenic perturbations. This is related to the typical mixing and residence times of the deep and bottom waters of the oceans, which are of the order of 1000 years. Thus studies in areas where interactions between the deep and the surface ocean occur, such as the Southern Ocean with the Weddell Sea, are extremely useful for the study of CO_2 uptake and its distribution.

While the atmospheric CO_2 increase is well documented, the oceanic increase is hard to monitor due to the high natural variations and the large amount of CO_2 present in the oceans. Our overall objective is to trace the anthropogenic CO_2 in the deep and surface waters of the Antarctic Ocean and to investigate what factors exert influence on the CO_2 distribution. Substantial progress in these issues can only be made when data series become available. Data from this cruise will extend the longest combined oceanic time series (since 1984) of CO_2 and transient tracers, hydrography, nutrients and oxygen at the prime meridian.

Work at sea

CO_2 parameters have been investigated along a latitudinal section at the Prime Meridian, one section northeast to southwest across the Weddell Sea from the Prime Meridian to about 23°E, and one quasi-latitudinal section along 23°E crossing the entire Weddell Gyre at that location (see Figure 2.1-1). Parameters that were measured include the total inorganic carbon content (TCO_2) and the partial pressure of CO_2 (pCO_2). Vertical TCO_2 profiles of the entire water column were determined from discrete water samples taken from the rosette sampler. About 2000 water samples were analyzed, i.e. at almost all hydrographic stations, where generally a triplicate analysis was made for each sample. The pCO_2 was determined in the surface water quasi-continuously from the sailing ship.

TCO_2 was determined by a high-precision coulometric method using an automated sample stripping system. Briefly, the method is as follows. A sample of seawater is acidified with phosphoric acid and stripped with high-purity N_2 gas. The extracted CO_2 is, with the N_2 carrier gas, passed through a solution containing ethanolamine and an indicator. This solution is electrochemically back-titrated to its original colour and the amount of coulombs generated is equivalent to the amount of CO_2 in the sample. The measurements are calibrated and corrected against an internationally recognized TCO_2 standard (obtained from Prof. Dickson of Scripps, U.S.A.).

Continuous measurements of the pCO_2 in water and marine air were done using an infra-red analyzer (Li-Cor). A continuous water supply is passed through an equilibrator, where every minute the headspace gas is analyzed for its CO_2 content, thus giving pCO_2 in the surface water. Marine air was pumped continuously from the crow's nest into the laboratory and sub-sampled every three hours. The measurements are calibrated with standard NOAA gases. As the pCO_2 is strongly dependent on temperature changes, final data will only be available pending corrections for the temperature increase of the water while flowing from the ship's keel into the laboratory. Analyses of TCO_2 and online pCO_2 were performed using equipment put at our disposal by the Royal Netherlands Institute for Sea Research (NIOZ, Texel).

At a few stations $pCO_2$was measured at samples throughout the water column as drawn from the rosette. This was done using a discrete pCO_2 analysis system of the University of East Anglia.

Preliminary results

Total carbon dioxide

Unfortunately, we cannot as yet present final results for TCO_2 and PCO_2. Some general patterns can be discerned, though. A general feature of the TCO_2 distribution is that, although the TCO_2 values in the Southern Ocean surface water are high compared to other surface ocean regions, they are low in comparison with the deep and bottom water. The TCO_2 minimum in the surface water is due to phytoplankton which utilises CO_2. Below the thermocline, a TCO_2 maximum is found associated with the temperature maximum of the Warm Deep Water (WDW). Near the bottom relatively low TCO_2 values were measured in Weddell Sea Bottom Water (WSBW). This water mass originates partly from the shelf waters of the Weddell Sea, which are low in TCO_2.

Partial pressure of CO_2

The measurement of pCO_2 during the entire cruise period resulted in a large, high spatial resolution data set. Mostly modest under- and over-saturation were observed in the area of investigation. However, two regions fall outside this trend. At the Prime Meridian the region contiguous to the Antarctic continent showed dramatic undersaturation. This includes not only the coastal area, but also the region further offshore. The other large region with large under-saturation is the northeastern Weddell Gyre along 23°E. Such strong under-saturation can only be caused by intense phytoplankton primary production in these regions.

2.8 Investigations on physical hydrography: Weddell Sea Convection Control - WECCON

Since 1996 moorings were deployed along the Prime Meridian (Figure 2.8-1) and redeployed every two years, as was done during this cruise. The two southernmost moorings covered the area of the coastal current. Westward of Maud Rise there are three moorings equipped with temperature-conductivity recorders from approximately 250-750 m depth to monitor the change in the stratification. This data are imported to study the possible pre-conditioning for the occurrence of a polynya. The four northern moorings are at the westward flowing branch of the Weddell Gyre and the transition into the Antarctic Circumpolar Current (ACC). This region is characterized by fronts, which also effect the elevation of the sea surface. Thus bottom pressure recorders in the three northernmost moorings are used to record the change of the sea surface elevation and from these records the shift of the ACC can be determined. The sea surface elevation was compared with the satellite sea surface height measurements from TOPEX/Poseidon. The ACC was also described with the full coverage of temperature conductivity recorders in this region. Inverted echo sounders are placed on top of the six southern moorings to measure the sea-ice draft and the variability of the yearly sea ice coverage. The instrumentation of the deployed moorings (Table 2.8-2) has not changed compared to the instrumentation of the recovered moorings (Table 2.8-1) but in addition two sound sources have been attached in mooring 229 and 231 at 850 m depth each. A third sound source was deployed as a single sound source mooring near 10°E

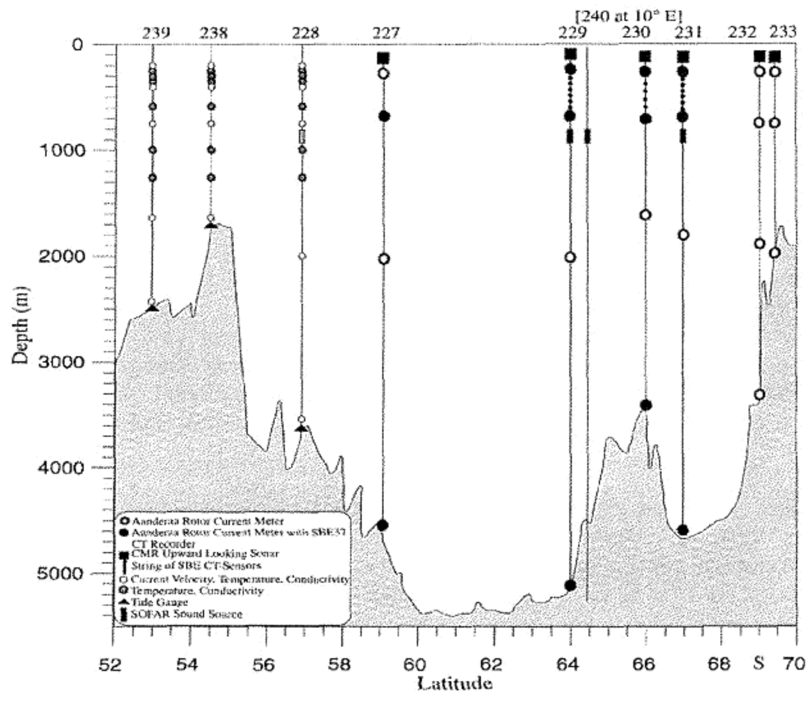


Figure 2.8-1: *Vertical section along the Prime Meridian with the moored instruments.*

Mooring AWI227 to AWI239 are the moorings which have been replaced. In addition sound sources were attached in moorings AWI229, AWI231, and in AWI240 which is a newly deployed one at 10°E.

The mooring work started with mooring AWI239 and the first part ends with mooring AWI229 before steaming on direct course to Neumayer Station. After the supply activities the mooring work was continued from the south, starting with mooring AWI233 towards mooring AWI230. The sound source mooring AWI240 was deployed on the south-east transect to the GeoBox (see Figure 2.1-1). The two northern moorings were replaced in open water. Due to rough weather conditions the deployment of AWI239 was stopped. The next day conditions became slightly better and the deployment could be finished. The sea ice edge was found north of AWI227 and at the mooring position the ice coverage ranged from 8/10 to 9/10. All further moorings were recovered under extremely closed ice cover with only a few small leads. Because the prototype of an acoustic unit (TT801) failed, the Posidonia positioning system was used. The successful recovery of all moorings during this cruise suggests that Posidonia may warrant a complete recovery even under difficult ice conditions. It was the first successful use of Posidonia for mooring recovery, therefore the following section exemplifies the recovery routine of one of our moorings.

2.8.1 Mooring recovery with Posidonia

Posidonia is an acoustic ultra short baseline positioning system of the IXSEA OCEANO company (France). The transducer array is fixed on a platform to be installed in the ships moon pool. The moon pool is locked when breaking through the ice. Thus the transducer array can only be installed on station and further ice breaking is not possible. Only cautious maneuvering of the ship within leads is possible once the transducer array is installed. The installation of the transducer array occupies approximately 45 minutes. The Posidonia processing unit is connected to the ships navigation system as well to the pitch and roll sensors. The system was operated from a PC with special positioning software. The system is able to track acoustic transponders which can be placed on underwater vehicles or in moorings. These transponders must be Posidonia compatible transmitting multi frequency shifted key (MFSK). One of the moorings double releases can transmit MFSK and also one transponder at the moorings top. Thus it was possible to position and track at least one unit. The release command can be generated for Posidonia compatible releases. The PC was placed on the bridge and therefore one can directly communicate with the navigation officer during the mooring positioning and release.

The transducer array was installed when *RV POLARSTERN* had reached a lead close to the mooring location. Afterwards the positioning software was started and the transponder/releaser set-ups were loaded into the program from the configuration file, which is needed for Posidonia compatible transponders. Before the transponders can reply on their specific interrogate frequency for positioning, an enable command has to be transmitted. When this command is confirmed, the main positioning routine starts. It shows two graphs for plotting the horizontal and vertical distances between the ship and the transponder. Another window displays the calculated transponder position in latitude, longitude and depth in meters. There is also a status window, showing which of the four receivers detected a signal from the transponder. An interrogate signal was transmitted every five seconds. As soon as all four receivers have detected a reply from the transponder, its position is displayed. For moorings that have been deployed with the anchor first, the position measured with Posidonia was the same as being noticed after the deployment. For moorings that have been deployed in open water with anchor last, it was found that the position was not very far off the calculated position. Once Posidonia has found the position of the mooring the navigation officer sets a marker from this position or the radar screen, which shows the surrounding sea ice field. If the mooring was in a region of heavy sea-ice coverage the mooring was not released. Instead the ice drift was observed to find a lead passing the mooring. As soon as a lead has reached the mooring position a release command was send. This can be done directly from the Posidonia software. After the release positioning was continued and the Posidonia PC-display shows decreasing transponder depth. It occurred that the moorings top-floats appeared directly in the assumed 50 m wide lead. Because the mooring will drift with the current, which may set differently than the drifting sea ice, the mooring can miss the lead. In this case the positions from the Posidonia system help to fix the region to search for float packages, which may appear between the ice flows.

Even in open water Posidonia helps to improve the mooring recovery. It was found that release commands being transmitted with the standard deck units (TT301 and TT801) and the 30 m cable hand-held-transducer failed if the release is placed in very deep water (greater 4000 m). During this cruise it could be verified that the release did not fail if the ship's noise was reduced disconnecting the propellers. But Posidonia transmitted release codes are able to release deep moorings even with running propellers or thrusters.

2.8.2 Iceberg tracking

To estimate the fresh water transport by icebergs, 10 satellite tracked transmitters were deployed there upon. These iceberg markers were manufactured by the "Denk Manufaktur" company, Gr. Kneten, Germany. The markers determine their position once per day at noon with a GPS receiver. The positions are transmitted via satellite using the ARGOS system. The ARGOS transmitter is switched on for six hours once a week only, to send the positions from the past seven days. The transmitter's on-time lasts long enough to ensure that all data can be received by CLS in Toulouse, France. This weekly transmission mode was chosen to save CLS service costs. Three markers are equipped additionally with an air pressure sensor. The ARGOS transmitters of these markers are operating in a 90 seconds continuous mode, providing three hourly air pressure data to the GTS. The iceberg markers are designed to operate for up to two years. Due to environmental aspects, the housing is slightly enlarged compared to previous versions. Thus the new markers have positive buoyancy without using additional floats. Markers from melted icebergs are likely to leave the Antarctic Ocean by drifting northwards and being entrained into the Antarctic Circumpolar Current. Tilt sensors are installed to detect when an iceberg begins to capsize. The ARGOS transmitter will switch into a continuous mode as soon as the tilt is excessive.

A helicopter was used to deploy markers on icebergs. Figure 2.8-2 shows the locations of the marked icebergs. The icebergs were chosen along the cruise track with a maximum flight distance of 20 nautical miles. Three markers were deployed during the supply activities at Neumayer Station. A digital photograph was taken to describe the shape of the iceberg. The length and width was measured with the GPS, flying along and across the iceberg. The height above sea level is taken from the radar altimeter of the helicopter. Table 2.8-3 gives a summary of all icebergs marked. Snow was sampled for the tracer group from IUPB.

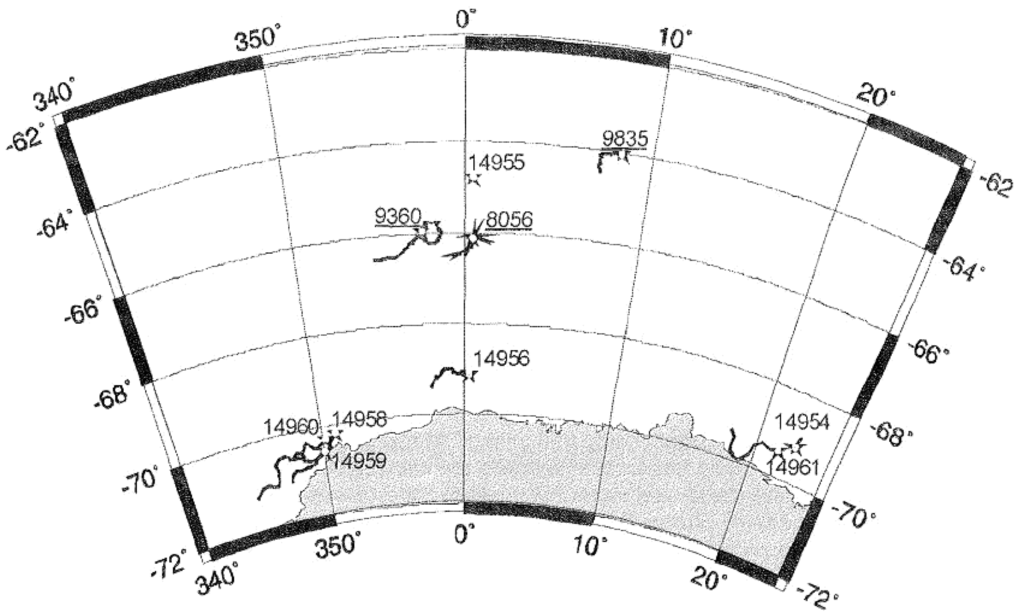


Figure 2.8-2: *Map of the ice bergs with deployed ARGOS transmitters. Numbers are the ARGOS Ids. Underlined Ids indicate the transmitters that are additionally equipped with air pressure sensor. The drift is shown for the period given in Table 2.8-3.*

Data collection from CLS via direct computer link and to do the data processing and validation is assigned to Optimare company, Bremerhaven, Germany. Daily updated iceberg tracks are available from Gerd Rohardt (grohardt©awi-bremerhaven.de).

2.8.3 Deployment of pressure inverted echo sounders - PIES

To monitor the Antarctic Circumpolar Current (ACC) transport, two Pressure Inverted Echo Sounders (PIES) were purchased from the University of Rhode Island and deployed across the ACCs. The instruments are located on the TOPEX/Poseidon ground track number 133 (Figure 2.8-3), complementing a PIES array between the South African coast and about 40°S, which is currently being deployed by Deidre Byrne, University of Maine along the same satellite ground track.

PIES deliver bottom pressure and travel times of sound signals from the bottom to the sea-surface, effectively providing a measure of average temperatures, bottom pressure variations and sea surface height. After the planned recovery of the instruments in austral summer 2004/2005, the data shall be used to extract baroclinic and possibly barotropic transport variations within the gap spanned by the PIES.

A high resolution bathymetric profile between Cape Town and the two PIES was recorded with the Hydrosweep System (Figure 2.8-4 and Figure 2.8-5).

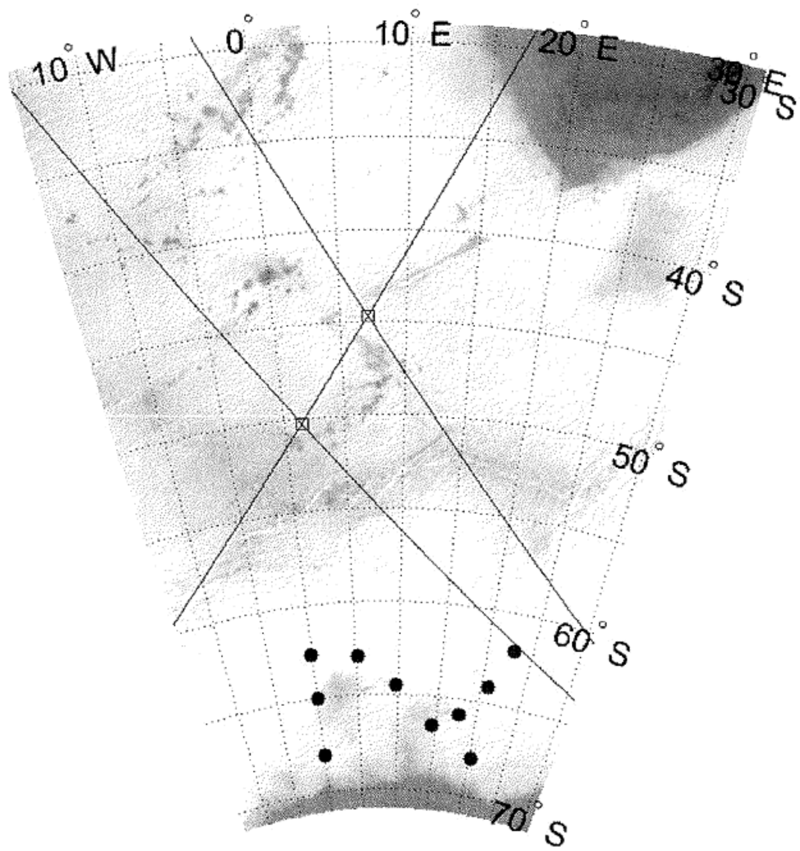


Figure 2.8-3: *Map of Pressure Inverted Echo Sounders (PIES) deployment positions (square boxes near 45° and 50°S at the crossover points of TOPEX/Poseidon tracks 133, 98 and 48) together with selling positions often freely drifting ARGO/APEX floats. Bottom topography from Smith & Sandwell.*

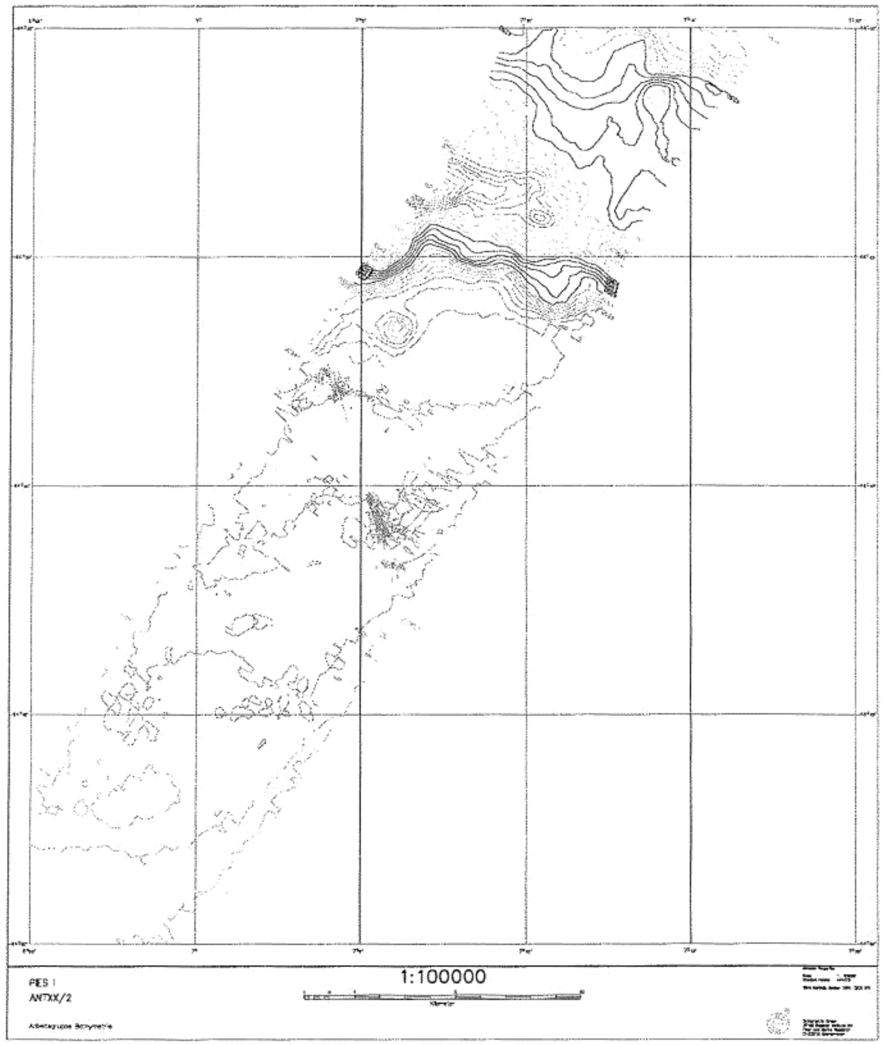


Figure 2.8-4: *Bathymetry around deployment position of PIES-1 at 44°39.75'S, 7°05.03'E. The bathymetry was recorded by Hydrosweep during cruise ANT-XX/2. Isobaths are spaced by 50 m.*

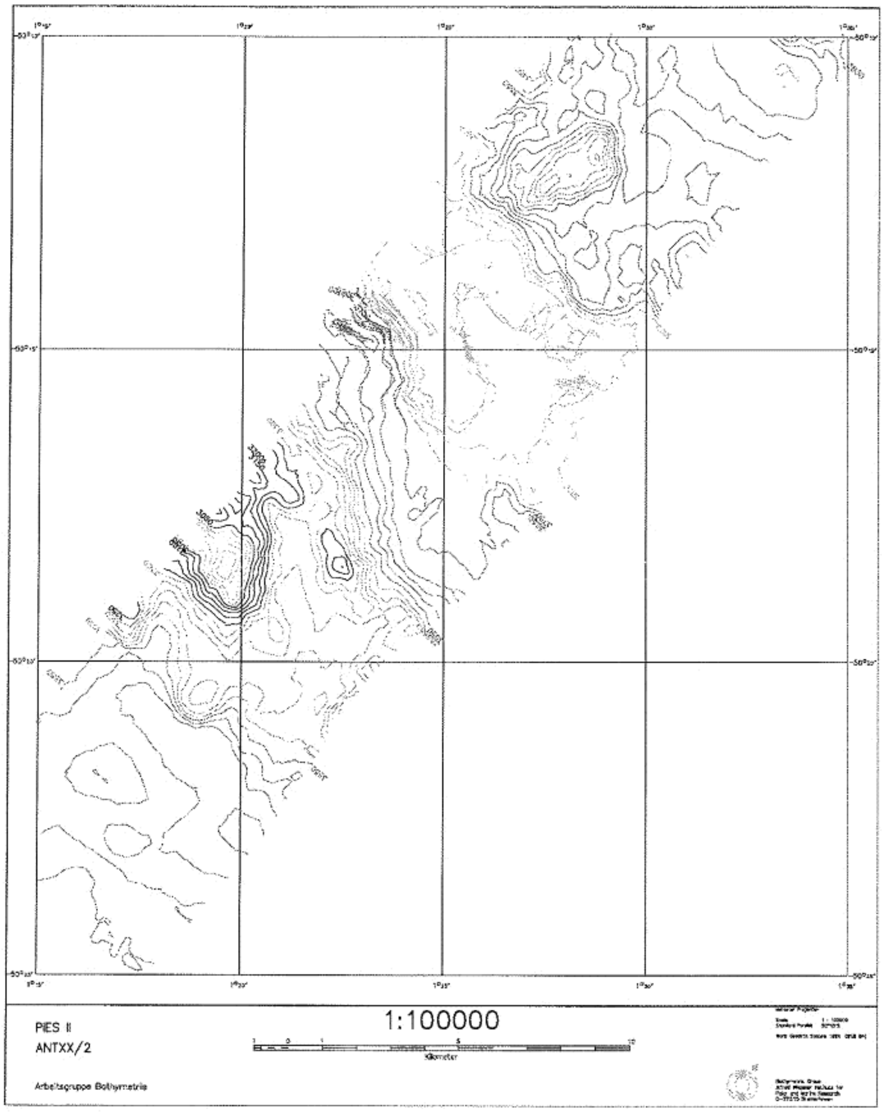


Figure 2.8-5: *Bathymetry around deployment position of PIES-I at 50°15.01'S, 1°25.00'E. The bathymetry was recorded by Hydrosweep during cruise ANT-XX/2. Isobaths are spaced by 50 m.*

2.8.4 Deployment of ARGO/APEX floats

The international ARGO (Array of Real Time Global Oceanography) project aims to set on the order of 3000 profiling floats into the world ocean to establish a real-time operational data stream of upper (<2000 m) ocean temperature and salinity profiles. Since 2001 the AWI contributes to this program with nine APEX floats, roving primarily between 50-60°S, which cycle every seven days between the sea surface and their drift depth near 800 m. This year the fleet that was augmented by another ten floats, set south of 60°S and cycling at ten days intervals (Figure 2.8-3).

2.8.5 Deployment of RAFOS floats and sound source moorings at Maud Rise

The Ranging and Fixing of Sound (RAFOS) technology has been used widely in moderate latitudes to provide high-resolution trajectories of neutrally buoyant floats by means of underwater acoustics. It is based on travel time measurements of a coded sound signal between a moored sound source and the moving float. However, at high latitudes, this technique is expected to work at considerable shorter ranges only, and the Maud Rise RAFOS Experiment (MARE) is designed as a first test to explore the ranges to be expected, while simultaneously trying to unveil the mesoscale circulation patterns around Maud Rise. To this end, three sound sources were moored and nine floats were launched in the vicinity of Maud Rise (Figure 2.8-6, Table 2.8-6 and Table 2.8-7).

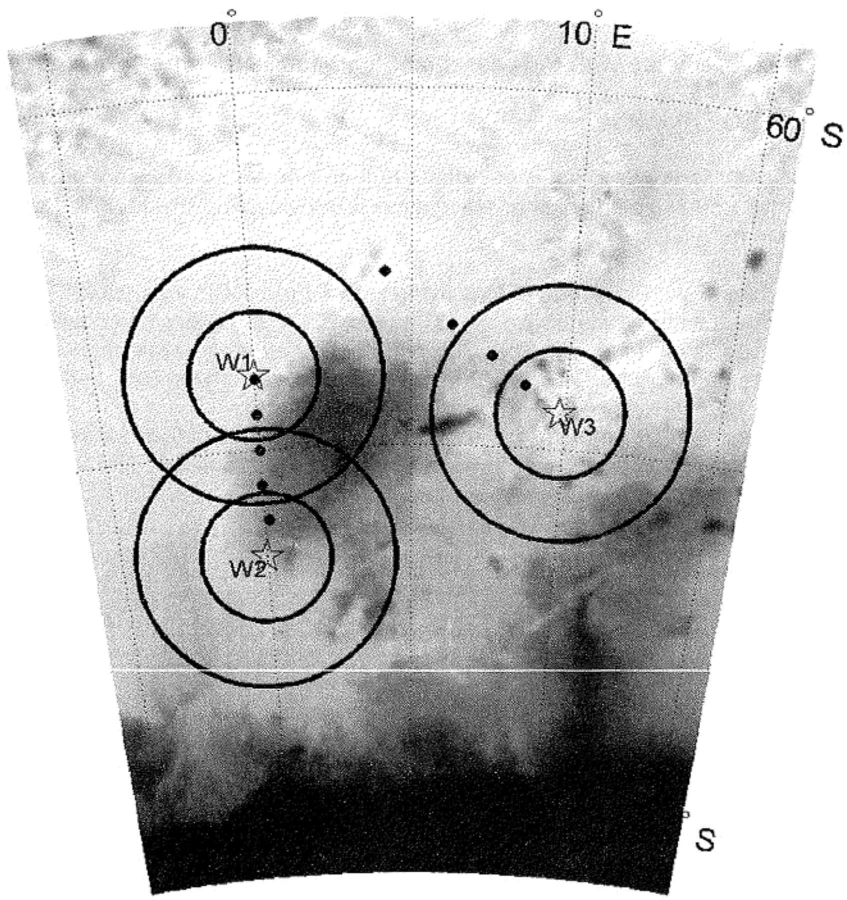


Figure 2.8-6: *Map of Sound Source moorings and RAFOS float deployment sites around Maud Rise. Asterisks mark the sound source mooring positions, with circles indicating 100 and 200 km ranges. Dots mark the setting positions of nine RAFOS (Ranging and Fixing of Sound) floats. Bathymetry according to Smith & Sandwell.*

The sources are refurbished sources, with some major problems that could only provisionally be fixed in Bremerhaven before shipment. Sound source 21 showed signs of previous leakage at the high voltage feed-through, which was provisionally fixed with Scotch Fill. Sound source 19 and 21 could only be addressed through the internal interface and hence could not be vacuum checked before deployment. Sound source 49/14 had the high voltage feed-through replaced and spliced to the external cable leading to the transducer.

2.8.6 Measurements with the vessel mounted acoustic Doppler current profiler VM -ADCP

AWI, OPTIMARE

A 150 kHz ADCP is mounted in the ship's hull and monitors continuously the velocity profile in the upper water column. Navigation is provided by the Marine Inertial Navigation System (MINS).

Due to problems with one of the four transducers the ADCP was run in the 3-beamsolution mode for the whole cruise up to January 3, 2003, when it was switched off for repair. The decision to switch the VM-ADCP off that early, was made to take the opportunity to demount the instrument in calm weather conditions near the ice edge.

The instrument will be sent to the manufacturer RD Instruments for repair after the cruise. A preliminary scan through the data indicates no problems. The final processing will be done with the CODAS software at home.

Table 2.8-1: *Moorings recovered at the Prime Meridian. ADCP = RDI Inc. self contained acoustic doppler current profiler. ACM-CTD = Falmouth Scientific Inc. three-dimensional acoustic current meter with CTD head (CTD = Conductivity, Temperature, Depth). AVTCP = Aanderaa current meter with temperature-, conductivity-, and pressure sensor. AVTP Aanderaa current meter with temperature and pressure sensor. AVT = Aanderaa current meter with temperature sensor. RCM 11 = Aanderaa Doppler current meter. SBE16 = Seabird Electronics SBE16 recording temperature, conductivity, and pressure, ULS = Christian Michelsen Research Inc. upward looking sonar to measure the sea ice draft. SBE26 = Seabird Electronics SBE26 bottom pressure recorder. CT = Seabird Electronics SBE37 recording temperature and conductivity. CT-P = Seabird Electronics SBE37 recording temperature, conductivity, and pressure.*

Mooring	Latitude Longitude	Water depth (m)	Date time of 1st record	Instrument type	Serial number	Instrument depth (m)	Record length (days)
AWI233-5	69°23.73'S	1916	20-12-00	ULS	42	191	725
	00°04.04'W		16:00	ACM	1569A	220	(1)
				AVT	9186	717	725
				ACM-CTD	1387A	1873	725
AWI232-5	68°59.49'S	3337	21-12-00	ULS	46	166	724
	00°02.18'W		16:00	ACM	1565A	225	(1)
				AVTCP	9214	732	5(2)
				AVT	9182	1778	724
				ACM-CTD	1447A	3284	724
AWI231-4	66°30.00'S	4515	23-12-00	ULS	47	179	724
	00°01.80'W		10:00	ACM-CTD	1456A	198	(1)
				CT	237	250	724
				CT	238	300	724
				CT	239	350	724
				CTD	245	400	724
				CT	240	450	724
				CT	435	500	724
				CT-P	1231	550	(3)
				CTD	247	600	724
				CT-P	1232	650	724
				ACM-CT	1442A	705	724
				AVT	10003	1811	724
				ACM-CTD	1472A	4472	(1)

Mooring	Latitude Longitude	Water depth (m)	Date time of 1st record	Instrument type	Serial number	Instrument depth (m)	Record length (days)
AWI230-3	66°00.34'S	3447	23-12-00	ULS	36	170	724
	00°10.38'E		20:00	ADCP	1600	187	(4)
				AVTP	9204	195	724
				CT	236	295	724
				CTD	243	395	724
				CTD	244	495	724
				CT-P	1230	595	724
				ACM-CTD	1474A	705	724
				AVT	9785	1598	724
				ACM-CTD	1470A	3404	(1)
AWI229-4	63°57.86'S	5167	26-12-00	ULS	24	127	713
	00°02.40'E		18:00	ACM-CTD	1450A	170	(1)
				CT	228	220	713
				CT	230	270	713
				CT	232	320	713
				CTD	241	370	713
				CT	233	420	713
				CT	235	470	713
				CT-P	1288	520	713
				CTD	242	570	713
				CT-P	1229	620	713
				ACM-CTD	1443A	677	713
				AVT	9391	1973	74(2)
				ACM-CTD	1451	5117	(1)
AWI227-7	59°04.20'S	4620	29-12-00	ULS	08	148	(4)
	00°04.40'E		14:00	AVTCP	9194	252	707
				AVTCP	9998	679	707
				SBE16	2422	680	637
				AVT	9179	1986	707
				AVT	9211	4596	707
				SBE16	631	4597	(4)
AWI228-5	56°57.61'S	3712	30-12-00	ACM	1553A	205	(1)
	00°01.40'E		16:00	SBE16	2416	206	551
				Micro-J	1324F	256	411
				CT-P	1235	306	704
				CT	224	356	704
				AVTP	10541	413	704
				SBE16	630	414	(4)
				SBE16	319	575	(4)
				AVT	9180	741	704
				CT	229	742	704
				CT-P	1603	992	704
				CT-P	1604	1242	704
				AVT	9190	1948	704
				RCM11	20	3649	704
				SBE26	227	3712	(4)

Mooring	Latitude Longitude	Water depth (m)	Date time of 1st record	Instrument type	Serial number	Instrument depth (m)	Record length (days)
AWI238-3	54°30.60'S	1700	31-12-00	ACM	1567A	176	701
	00°0170'E		16:00	SBE16	2415	187	625
				CT	231	227	701
				CT-P	1234	327	701
				AVTP	9193	383	701
				SBE16	1167	384	701
				CT-P	1237	550	701
				AVTP	10926	730	701
				SBE16	1979	731	697
				CT-P	1605	981	701
				CT-P	1606	1231	701
				RCM11	25	1610	701
				SBE26	228	1700	(4)
AWI239-2	52°00.66'E	2460	03-01-01	ACM	1558A	218	697
	00°00.93'E		02:00	SBE16	2414	219	496
				CT-P	1233	269	697
				CT	216	319	697
				CT	225	369	697
				AVTP	10927	426	697
				SBE16	1977	427	566
				CT-P	1236	597	697
				AVTP	10928	773	697
				SBE16	1978	774	584
				CT-P	1607	1024	697
				CT	269	1274	697
				AVTP	12325	1780	697
				CT	227	1781	697
				RCM11	26	2407	697
				SBE26	276	2460	697

Remarks: Instrument failure no data recorded; Instrument flooded = data lost; Instrument lost during recovery; Memory download failed, has to be done by manufacturer.

Table 2.8-2: *Moorings deployed at the Prime Meridian and sound source mooring northeast of Maud Rise. AVTCP Aanderaa current meter with temperature, conductivity, and pressure sensor; AVTP = Aanderaa current meter with temperature and pressure sensor; AVT Aanderaa current meter with temperature sensor; RCM 11 = Aanderaa Doppler current meter; SBE16P# = Seabird Electronics SBE16 recording temperature, conductivity, and pressure; here P# indicates the pressure range e.g. P1 for 1000 psi; ULS Christian Michelsen Research Inc. upward looking sonar to measure the sea ice draft; SBE26 = Seabird Electronics SBE26 bottom pressure recorder: SBE37-Seabird Electronics SBE37 recording temperature and conductivity, SBE37Pu = Seabird Electronics SBE37 recording temperature and conductivity with external pump; SBE37PuP# = Seabird Electronics SBE37 recording temperature, conductivity, and pressure with external pump; here P# indicates the pressure range e.g. P1 for 1000 psi; SQ-Sound source for SOFAR-Drifters.*

Mooring	Latitude Longitude	Water depth (m)	Date time of 1st record	Instrument type	Serial number	Instrument depth (m)
AWI233-6	69°23.66'S	1948	15-12-02	ULS	49	165
	00°03.98'W		22:48	AVTP	8367	237
				AVTCP	8395	738
				SBE37	1604	1891
				AVT	10499	1892
AWI232-6	68°59.87'S	3369	16-12-02	ULS	50	175
	00°00.32'E		14:46	AVTP	11887	252
				AVTPV	8396	765
				AVT	10498	1809
				SBE37	1605	3314
				RCM11	127	3315
AWI231-5	66°30.56'S	4552	18-12-02	ULS	39	178
	00°02.03'W		10:55	AVTCP	8400	220
				S3E37	2609	220
				SBE37	211	270
				SBE37	2610	320
				SBE37	214	370
				SBE37	215	420
				SBE37Pup3	2392	470
				SBE37	220	520
				S8E37	222	570
				SBE37	223	620
				S3E37	2234	670
				SBE37Pu	2382	720
				AVTCP	9215	731
				SQ	18/W2	882
				AVT	9768	1837
				SBE37Pu	2383	4492
				RCM11	133	4498
AWI230-4	66°00.30'S	3477	18-12-02	ULS	38	177
	00°10.29'E		20:53	AVTCP	8401	220
				SBE37Pu	2384	220
				SBE37Pu	2385	320
				SBE37P3	249	420
				SBE37	445	520
				SBE37	446	620
				SBE37Pu	2386	720
				AVTCP	9995	731
				RCM11	134	1627
				SBE37Pu	2087	3427
				RCM11	135	3433

Mooring	Latitude Longitude	Water depth (m)	Date time of 1st record	Instrument type	Serial number	Instrument depth (m)
AWI227-8	59°0420'S	4566	07-12-02	ULS	41	162
	00°04.47'E		09:01	AVTCP	10004	274
				AVT	3570	704
				SBE37PuP3	2395	705
				AVT	10503	2011
				SBE37Pu	2091	4616
				RCM11	146	4622
AWI229-5	63°57.23'S	5200	10-12-02	ULS	38	147
	00°00.21'W		18:45	AVTP	8402	193
				5BE37P3	2387	200
				SBE37	250	250
				SBE37	448	300
				SBE37	449	350
				SBE37Pu	2086	400
				SBE37PuP3	2393	450
				SBE37Pu	2088	500
				SBE37Pu	2089	550
				SBE37Pu	2090	600
				SBE37	2611	700
				SBE37PuP7	1564	750
				AVTP	9783	704
				SQ	14/W1	659
				RCM11	144	2005
				SBE37Pu	2388	5150
				RCM11	145	5156
AWI228-6	56°57.64'S	3699	04-12-02	AVTCP	8405	190
	00°01.62'E		23:00	SBE16P1	19783	191
				SBE37PuP3	2235	241
				SBE37Pu	2092	291
				SBE37Pu	2093	341
				AVTCP	9201	402
				SBE37Pu	2391	403
				SBE37PuP3	2396666	562
				AVT	9389	728
				SBE37Pu	2094	729
				SBE37Pu	2095	979
				SBE37PaP7	1565	1227
				RCM11	100	1934
				RCM11	101	3635
				SBE37Pu	2389	3636
				SBE26	276	3699

Mooring	Latitude Longitude	Water depth (m)	Date time of 1st record	Instrument type	Serial number	Instrument depth (m)
AWI238-4	54°30.63'S 00°01.81'E	1718	03-12-02 14:20	AVTP	11892	187
				SBE16P3	2420	188
				SBE37Pu	2096	238
				SBE37Pu	2097	288
				SBE37Pu	2098	338
				AVTP	10491	399
				SBE37FuP3	2236	400
				SBE37Pu	2099	570
				AVT	9390	745
				SBE37PuP3	2237	746
				SBE37Pu	2100	1000
				SBE37Pu	2101	1250
				RCM11	102	1651
				SBE37Pu	2390	1652
				SBE26	257	1718
AWI239-3	53°00.49'S 00°01.96'E	2483	02-12-02 18:03	AVTCP	8419	240
				SBE37Pu	2231	241
				SBE37Pu	2102	291
				SBE37Pu	2103	341
				SBE37Pu	2104	391
				AVT	9401	441
				SBE37PuP3	2394	442
				SBE37Pu	2105	613
				AVT	9458	797
				SBE37PuP3	2238	798
				SBE37Pu	2233	1043
				SBE37PuP7	1566	1293
				RCM11	103	1793
				SBE37	2232	1804
				RCM11	104	2429
				SBE26	261	2483
AWI240-1	64°30.00'S 10°00.00'E	5200		SQ	new	856

Table 2.8-3: *Deployment of ARGOS transmitters on icebergs.*

ARGOS identification	Date and time of - deployment - last position	Latitude Longitude	Iceberg dimension L - W - H (m)	Remarks	Digital photo (JPG)
9360	11-12-02 / 11:36 13-01-03 / 12:00	65°57.15'S 02°28.89'W	200 - 200 - 25	inclusive air pressure sensor	EB1
14959	13-12-02 / 15:09 10-01-03 / 12:00	70°20.88'S 08°20.44'W	1600 - 750 - 40	tritium snow sample taken	EB2
14958	13-12-02 / 15:30 10-01-03 / 12:00	70°13.61'S 07°57.00'W	380 - 380 - 25	tritium snow sample taken	EB3
14960	14-12-02 / 12:54 11-01-03 / 12:00	70°16.63'S 09°39.85'W	380 - 380 - 40	tritium snow sample taken	EB4
14956	16-12-02 / 13:25 12-01-03 / 12:00	69°06.05'S 00°29.81'E	380 - 380 - 20	tritium snow sample taken	EB5a EB5b

ARGOS identification	Date and time of - deployment - last position	Latitude Longitude	Iceberg dimension L - W - H (m)	Remarks	Digital photo (JPG)
8056	18-12-02 / 13:56 13-01-03 / 12:00	66°07.24'S 00°24.79'E	180 - 180 - 10	inclusive air pressure sensor	EB6a EB6b
14955	19-12-02 / 09:30 22-12-02 / 12:00	64°52.09'S 00°16.97'E	180 - 180 - 50	tritium snow sample taken	EB7
9835	23-12-02 / 09:00 10-01-03 / 12:00	64°01.33'S 08°17.02'E	200 - 100 - 15	inclusive air pressure sensor capsized	EB8a EB8b EB8c
14954	29-12-02 / 15:25 12-01-03 / 12:00	69°10.98'S 22°32.06'E	100 - 300 - 30	tritium snow sample taken	EB9a EB9b
14961	29-12-02 / 16:09 12-01-03	69°24.07'S 21°34.69'E	300 -300 - 35	Tritium snow sample taken	

Table 2.8-4: *PIES mooring positions. Times are set according to GPS time, which was 14 S late (GPS = UTC + 14 s) relative to UTC during this period.*

Identifiers AWI project URI SN.	Start - date (DMY) - time (GPS)	Auto release - date - time	Launch wt. Depth (m) - Hydroswe. - PODAS	Latitude Longitude	Date / Time (UTC)	Speed (km/h)
PIES-1 67	26-11-02 18:46:37	26-12-06 20:00	4610 4613	44°39.75'S 07°05.03'E	27-11-02 16:42	1.9
PIES-2 69	28-11-02 16:09:55	26-12-06 20:00	3879 3930	50°15.01'S 01°25.00'E	29-11-02 21:56	2.5

Table 2.8-5: *ARGOS/APEX profiling float setting positions during ANT-XX/2. All floats feature an ice avoidance software feature, based on measurement of the median temperature between 50 and 20 m water depth. Float times are set according GPS time which was 14 slate (GPS = UTC + 14 s) relative to UTC during this period.*

Float number			Start			Launch				
AWI	ARG HEX	ARG DEC	Webb Res. SN	Date-GPS Time-UTC	Wt. Depth (m)	Latitude Longitude	Date Time (UTC)	Wave height	Wind (m/s)	Ice cov
40	90C64	25649	673	09-12-02 09:04:08	5337	62°37.84'S 00°05.81'W	09-12-02 15:32	0	13	5
41	9F3F1	26575	680	16-12-02 16:33:12	4512	68°00.28'S 00°03.49'W	17-12-02 03:44	0	2	5
42	A1965	26725	681	18-12-02 22:48:06	3757	65°00.32'S 00°00.41'W	19-12-02 11:13	0	5	4
43	A9096	10818	655	21-12-02 08:26:04	5172	62°57.27'S 05°16.46'E	22-12-02 09:54	1	5	0
44	90C91	25650	674	23-12-02 08:31:53	5214	64°29.48'S 09°49.45'E	23-12-02 15:43	0	9	1
45	91DC7	25719	675	25-12-02 14:59:45	3424	66°03.46'S 14°32.98'E	25-12-02 23:07	0	2	3
46	93890	25826	676	27-12-02 16:26:23	4045	67°59.98'S 20°13.58'E	28-12-02 13:33	0	5	2

Float number			Start			Launch				
AWI	ARG HEX	ARG DEC	Webb Res. SN	Date-GPS Time-UTC	Wt. Depth (m)	Latitude Longitude	Date Time (UTC)	Wave height	Wind (m/s)	Ice cov
47	95178	25925	677	06-01-03 18:02:00	4899	65°49.57'S 17°45.57'E	06-01-03 20:12	0	2	0
48	9F3A2	26574	679	08-01-03 10:18:32	5055	64°07.90'S 20°45.40'E	08-01-03 13:23	0	4	0
49	9518D	25926	678	09-01-03 19:30:00	5160	61°59.96'S 22°58.95'E	09-01-03 22:45	0	4	0

Table 2.8-6: *RAFOS float setting positions. Float times are set according to GPS time, which was 14 s late (GPS + 14 s) relative to UTC during this period.*

Float number				Start			Launch				
AWI	ARGO HEX	ARG DEC	Sea Scan	Start Date time GPS	Dive start Expected surf. date	Water Depth (m)	Latitude Longitude	Date Time (UTC)	Wave height	Wind (m/s)	Ice cov
01	4938F	4684	262	17-12-02 14:52	18-12-02 16-02-04	3497	66°00.27'S 00°10.30'E	18-12-02 20:28	0	0	7
02	49755	4701	263	17-12-02 14:38	18-12-02 16-02-04	3960	65°29.90'S 00°00.10'E	19-12-02 04:34	0	0	5
03	5FOEB	6083	270	16-12-02 18:50	17-12-02 17-02-04	3758	65°00.31'S 00°00.36'E	19-12-02 11:13	0	5	4
04	498F0	4707	264	17-12-02 18:31	18-12-02 16-02-04	4670	64°30.36'S 00°00.40'E	20-12-02 00:04	0	4	4
05	49E14	4728	265	17-12-02 18:21	18-12-02 16-02-04	5200	64°00.18'S 00°00.30'E	20-12-02 03:04	0	6	0
06	49E47	4729	266	20-12-02 18:12	21-12-02 17-02-04	5414	62°33.87'S 04°11.42'E	22-12-02 03:22	2	8	0
07	49EE1	4731	268	21-12-02 10:13	22-12-02 16-02-04	5383	63°17.97'S 06°15.10'E	22-12-02 18:43	1	3	0
08	5F101	6084	271	21-12-02 15:37	22-12-02 16-02-04	4926	63°43.23'S 07°32.18'E	23-12-02 02:05	0	5	3
09	49F0B	4732	269	22-12-02 08:42	23-12-02 17-02-04	5028	64°07.30'S 08°38.93'E	23-12-02 09:22	0	8	2

Table 2.8-7: *Position of sound source moorings.*

Identifiers				Start	Deployments				
AWI project	Sound source SN	Electr. SN	AWI mooring	Ping time (GPS)	Water Depth (m)	Latitude Longitude	Date UTC Time UTC	Wave height	Wind (m/s)
W1	49	14	229-5	00:35	5200	63°57.23'S 00°00.21'W	10-12-02 18:45	0	13
W2	19	19	231-5	01:05	4542	66°30.56'S 00°02.03'W	18-12-02 10:41	0	5
W3	21	21	240-1	01:35	5173	64°29.49'S 09°49.53'W	23-12-02 15:40	0	9

2.9 Tracer measurements

Hendrik Sander and Martha Schattenhofer

CFCs and Tritium are transient tracers of anthropogenic origin. Measured distributions of these tracers provide information on the renewal of subsurface water from the ocean surface layer on decadal time scales. Sections on the Greenwich Meridian investigated during ANT-X/4 (1992), ANT-XIII/4 (1996) and ANT-XV/4 (1998) were repeated to evaluate the increase of the tracer concentrations in time. The comparison between the atmospheric and the in-situ increase will be used to study transport processes. In addition new sections in the east will provide information of the inflow from the east into the Weddell Sea.

All samples taken during the cruise will be analyzed in the laboratory after the cruise. The waters samples for CFCs were taken from the rosette water sampler and were stored in flame-sealed ampoules for later analysis. Along the Greenwich Meridian 36 stations were sampled, along the section between 0° and the GeoBox thirteen stations, in the GeoBox six stations and along 23°E 14 stations. Overall 1007 water samples for CFCs were taken. They will be extracted after the cruise and analyzed with a mass spectrometer.

Snow samples for tritium measurements were taken at 25 locations along the entire cruise. This includes eight samples from icebergs, four samples from the shelf-ice and thirteen samples from ice floes. All gases will be extracted from the Tritium samples which will then be stored or half a year. After this time a sufficient amount of Tritium will have decayed to ^{3}He and can be measured by the mass spectrometer. This will help to improve the global Tritium input function and give more details about the local precipitation.

2.10 Naturally occurring radionuclides as tracers for water mass characterization

Claudia Hanfland, Walter Geibert, Ingrid Vöge and Olaf Boebel

Natural radioactivity in the oceans originates mainly from three sources: cosmogenic nuclides, ^{40}K and decay products of the naturally occurring decay chains ^{238}U, ^{235}U and ^{232}Th, Especially isotopes of the latter find a wealth of applications in the study of oceanic reaction and transport processes taking place on time scales from hours and days to years. According to their geochemical behaviour in sea water, the radionuclides can be grouped after their respective particle-reactivity. For example, given, radium and actinium tend to stay in solution while thorium or protactinium are quickly scavenged by particles and subsequently transported to the seafloor. Disequilibria between parent and daughter nuclides are the consequence of this partitioning. While particle transport processes are investigated by means of adsorption-prone isotopes, water mass studies rely on elements having a soluble behaviour. The supply of the rather mobile elements to the water column is mostly by diffusion from sediments through decay from a particle-reactive parent while their distribution in the water column is governed by their respective half-lives.

During expedition ANT-XX/2, ^{234}Th, ^{226}Ra, ^{228}Ra and ^{227}Ac have been sampled in surface waters and on selected vertical profiles. ^{234}Th has been measured in order to estimate the export production from the upper water column into deeper water layers and will be presented in further detail in the chapter 2.11.5. SYNPART Project.

^{226}Ra and ^{228}Ra sampling program

Both ^{226}Ra and ^{228}Ra (half-lives 1600 yrs and 5.5 yrs, respectively) are released to the water column from the sediment through decay of thorium isotopes, but in consequence of a difference in parent distribution and half-life, the release of ^{226}Ra is strongest from deep-sea sediments while ^{228}Ra accumulates to high activities in shallow water regions.

Sampling for ^{226}Ra has been carried out with regard to two objectives:

(1) the quantitative determination of ^{226}Ra provides a simple means to convert ^{226}Ra/^{228}Ra activity ratios into absolute ^{228}Ra activities (see below).

(2) It is the most abundant of the radium isotopes in open ocean waters and is best suited to study the biogeochemistry of radium in the marine environment, i.e. its behaviour as a biointermediate element.

Radium has been considered as a water mass tracer with a nutrient-like distribution (Broecker et al. 1967). Based on the similarity of vertical water column profiles of ^{226}Ra and Si, it was hypothesized that siliceous tests act as a main carrier phase for ^{226}Ra (Ku et al. 1970, Ku & Lin 1976). Given the predominance of diatoms over other phytoplankton species in the Southern Ocean, the relation should hold especially in circumpolar waters. However, results from previous cruises have indicated that the uptake of ^{226}Ra continues north of the Polar Front after the near depletion of Si, pointing to a decoupling of both parameters.

Besides the sub sampling necessary for the ^{228}Ra analysis, ^{226}Ra was sampled on three selected vertical water column profiles (Figure 2.10-1) in conjunction with nutrient analysis in order to get a better idea of the biogeochemical processes governing the distribution of ^{226}Ra in southern circum polar waters.

^{228}Ra has been used widely (e.g. Kaufmann et al. 1973, Reid et al. 1979, Moore et al. 1986, Rutgers van der Loeff et al. 1995) as a tracer for prolonged contact of water masses with continental shelf areas. It is a daughter product of ^{232}Th, which is common in most sediment types but nearly absent in sea water due to its particle reactive behaviour. In contrast, radium is soluble in sea water and can accumulate to high activities over fine-grained sediment. According to its half-life of 5.8 years, the activity of ^{228}Ra will decrease with distance from the source and is extremely low in the open ocean.

Dependant on the geographic region, the sampling for ^{228}Ra during ANT-XX/2 was performed under different aspects (Figure 2.10-1):

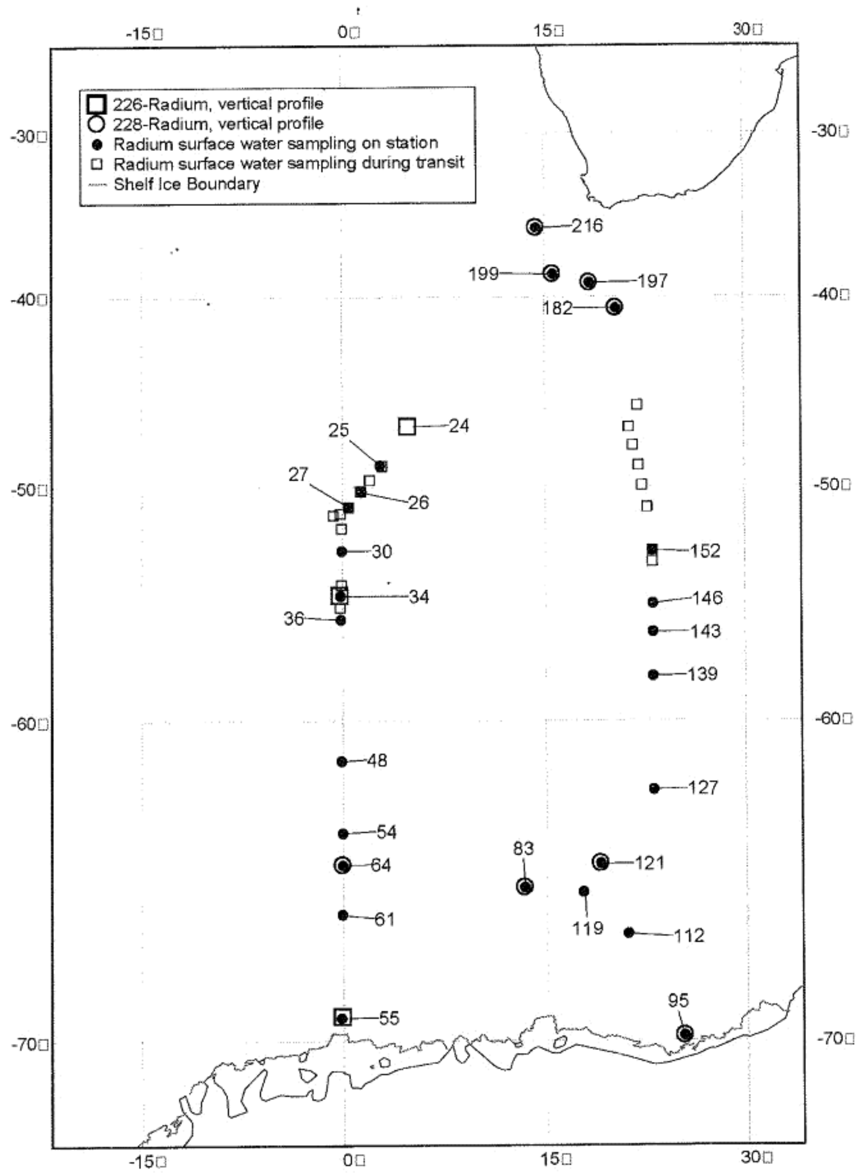


Figure 2.10-1: *sampling chart for radium and actinium during ANT-XX/2. Numbers refer to official stations, full labeling should read: PS63-xxx.*

Polar Frontal Region

In the context of iron as a growth-limiting factor for the primary productivity of the Southern Ocean, the oceanic fronts within the Antarctic Circumpolar Current (ACC) and especially the Polar Front have been suggested as effective transport mechanisms for iron released from continental shelf sediments and transported eastwards with ACC (de Baar et al. 1995, Löscher at al. 1997). If the shelf areas represent indeed important source areas of iron for the open South Atlantic, this should be mirrored by increased ^{228}Ra activities. Results from previous cruises indicate an ambiguous picture, pointing to rather sporadic inputs that are highly variable in both space and time. Hence, high resolution sampling of the Polar

Frontal Region along 0° and 23°E was done in order to get a better picture of the variability of possible shallow water inputs with the Polar Front.

South-Eastern Weddell Gyre

Inflow of North Atlantic Deep Water into the Weddell Gyre takes place in its southeastern corner (Orsi et al. 1993), a region where currently only very few natural radionuclide data are available for (Geibert et al. 2002, Hanfland 2002). The determination of ^{228}Ra will help to demarcate the extension of coastal waters into the Weddell Gyre.

Agulhas (Return) Current

Intense mixing of subtropical and subantarctic water masses takes place in the region south of South Africa. Occlusion of the retroflecting Agulhas Current generates rings that move northwestwards into the Atlantic while perturbations in the flow of the Agulhas Current lead to the spawning of both cyclonic and anticyclonic eddies (Lutjeharms 1996, Boebel et al. 2003). The mixing waters carry very distinct ^{228}Ra signals, a feature that should help especially in a better distinction of the origin of cyclonic eddies. While waters moving north from the Antarctic zone are typically low in ^{228}Ra, cyclones developing along the South African coast in the course of a Natal Pulse can be expected to carry a strong coastal signal.

Four stations had been sampled for ^{228}Ra within the Aguihas Retroflection Area (Figure 2.10-2):

PS 63-182. cyclonic eddy	PS 63-197: Agulhas Retroflection
PS 63-199: cyclonic eddy	PS 63-216: Agulhas ring

A highly variable, mesoscale flow field dominates the Agulhas Region. To obtain samples as close as possible to the end-members of each regime, an identification of these mesoscale features during the cruise was mandatory. Using steric sea-surface height anomalies (SSH data) from MODAS (Modular Ocean Data Assimilation System), the location of cyclones and anticyclones was achieved in real-time. Daily MODAS SSH fields were uploaded to *RV POLARSTERN* by the Stennis Space Center at the Naval Research Lab, Mississippi in real time. MODAS-SSH data have recently been shown to provide a highly reliable view of the overall distribution of the mesoscale flow field (Boebel & Barron 2003) in this region. Modulations in the SSH field are directly related to ocean currents, which flow along SSH isolines with higher SSH values to their left when looking downstream (Figure 2.10-2).

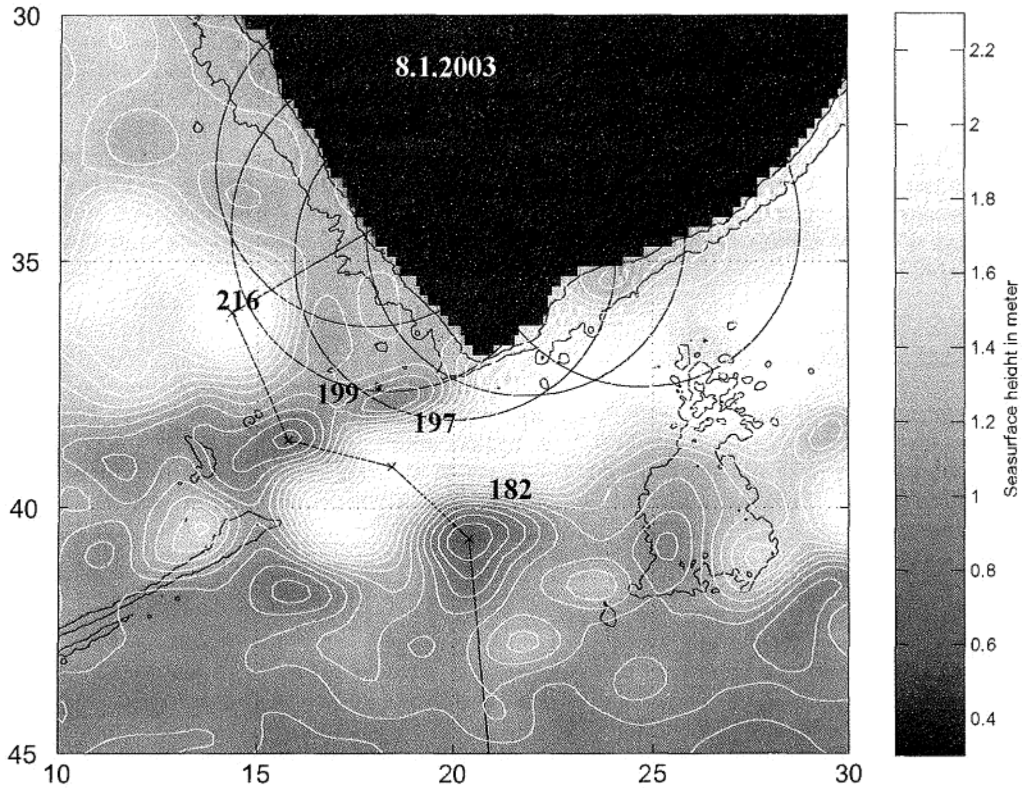


Figure 2.10-2: *Steric sea-surface height (SSH) from MODAS from January 18, 2003. Similar plots were produced for each day and the cruise track adjusted as to sample the water in each feature's centre.*

The reliability of the actual MODAS SSH fields was tested during the cruise by monitoring the depth of the 10°C isotherm. The latter should be located at depths around 800 m when an anticyclone is traversed, or alternatively, at 300-500 m when encountering cyclones. This was indeed the case when XBT casts succeeded, though between P563-197 and PS63-199 only few XBT profiles were collected due to bad weather.

Figure 2.10-2 shows the situation on January 18, 2003. The first eddy sampled near 40°37'S (PS63-182) shows a local SSH minimum and hence represents a cyclonic circulation pattern, which we traced back in time to a subantarctic origin. PS63-1, on the other hand, is located at the local SSH maximum indicative of the Agulhas Retroflection proper.

A cyclone north of the Agulhas Retroflection might have subantarctic (Atlantic) or subtropical/Indian origin (a Natal Pulse) or might have been formed locally (Boesel et al. 2003). One such cyclone has been probed during PS63-199. In contrast to the previous two locations, this feature is not expected to display end-members but a mix of Indian and Atlantic water types.

The same holds true for the last station in a matured Agulhas Ring (anticyclone) sampled during PS63-216. While travelling north, these features have been shown to entrain surrounding waters, which could be of subantarctic and/or subtropical origin.

^{227}Ac sampling program

^{227}Ac (half-life 21 yrs) is almost exclusively released from deep-sea sediments into bottom waters. Any excess activity over its parent nuclide ^{231}Pa in the upper water column indicates rapid upwelling of deeper water masses (Geibert et al. 2002). Sampling for ^{227}Ac at the sea surface follows the same procedure as described for ^{228}Ra (see below). Determination of the ^{227}Ac activity will be done on all surface water samples in the Weddell Gyre and on the vertical stations PS63-64, PS63-83 and PS63-121. The combined analysis of ^{227}Ac and ^{228}Ra will allow a better distinction of deep upwelling versus lateral input of water masses in the southeastern Weddell Gyre.

Additional sampling

Samples for the determination of ^{231}Pa and ^{230}Th in the water column were taken on three selected vertical profiles. These samples will be analyzed by the University of Kiel (group Scholten/Fietzke).

Additionally, three samples of Weddell Sea Deep Water were taken for the analysis of the isotopic composition of Cadmium (analysis by Rehkamper, ETH Zürich).

Methods

^{226}Ra

20 l of sea water were taken either directly from the ships sea water supply or sampled from the CTD. Surface water samples were run through a 1µm-prefilter to remove particulate matter. Particle concentrations from samples taken below the mixed layer were so low that filtering was not necessary. The samples were then weighed to determine the sample size. Even in rough seas, this is accurate to at least 100 g which equals an error of 0.5% for 20 kg. A pre-weighed aliquot (100 ml) of a $BaCl_2$-solution that had been prepared before the cruise was added under constant stirring to every 20 l water sample to precipitate radium as $Ba(Ra)SO_4$, making use of the natural sulfate content in sea water. After at least one hour of further mixing on the magnetic stirrer, the crystals were recovered by decantation and centrifugation and washed several times to remove any interfering ions.

At home, the dried and weighed precipitates will be filled in plastic tubes, sealed and set aside for about three weeks to allow the short-lived daughters ^{214}Pb and ^{214}Bi to grow into equilibrium with their parent ^{226}Ra. After establishment of a secular equilibrium, the sample will be counted by γ-spectrometry.

^{228}Ra and ^{227}Ac sampling was performed with MnO_2-coated cartridges that had been prepared before the cruise by immersion overnight at 70°C in a bath of a saturated $KMnO_4$ solution. The radionuclides get adsorbed on the MnO_2-coating. For surface water samples, a filter system was connected to the ship's sea water supply. The water sample was run through an uncoated cartridge (1 µm) for removing particulate matter, two MnO_2-coated cartridges put in series and a flowmeter for recording the sample volume. Typical sample volumes were between and 3 m^3. Sampling on vertical water profiles was performed with six time-programmed pumping units, equally loaded with a prefilter and two coated cartridges. The pumps were let on depth for 2.5 hrs and filtered about 1 m^3 of sea water.

In the home lab, the coated cartridges will be rinsed with deionised water and dried. Further processing of the samples involves acid-leaching of the cartridges, separation of the different isotope fractions by repeated precipitation and ion-exchange chromatography and determination of the respective activities by alpha- or gammaspectrometry. Due to their extremely low activities, ^{228}Ra and ^{227}Ac will be analyzed via their daughter-nuclides ^{228}Th and ^{227}Th, respectively (Moore 1972, Li et al. 1980, Geibert 2002).

As the adsorption of radionuclides on cartridges is seldom quantitaive, the results must be corrected for their efficiency (*E*). For ^{228}Ra, the cartridges yield $^{228}Ra/^{226}Ra$ activity ratios that are converted to absolute ^{228}Ra activities by means of the ^{226}Ra subsamples. ^{227}Ac is determined by using the cartridge formula: $E = 1 - B/A$, where A and B are the two cartridges put in line (Rutgers Van Der Loeff & Moore 1999).

For the determination of ^{227}Ac activities on depth profiles, it was planned to use a delayed coincidence counter system (Moore & Arnold 1996). However, when in operation on board, the counting unit proved to have several substantial problems. First, the manganese adsorbers dried within about half an hour, with the effect of large changes in counting efficiency. The counting of test samples showed additionally intervals of increased background activity. These intervals were irregular in time, and the activity too variable to allow reliable counting of the samples. Therefore, a different method of sampling was applied. To the water samples (12-60 l) NH_4OH, $KMnO_4$, and $MnCl_2$ were added in small amounts to produce a MnO_2 precipitation that adsorbs ^{227}Ac quantitatively. Later, the precipitate was filtered onto 142 mm diameter polycarbonate filters with 1 µm pore size. ^{234}Th was counted on the filters as a yield tracer for the MnO_2. Back in the home lab, the samples containing the ^{227}Ac will be dissolved, purified and counted via the more sensitive γ-spectrometric method.

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2.11 Geoscientific investigations

2.11.1 Bathymetric investigations in the eastern Weddell Sea

Sonja Gütz, Alexander Iffland and Anton Obermüller

During cruise ANT-XX/2 of *RV POLARSTERN* the swathsonar system Hydrosweep was used to obtain new bathymetric data from the Larazev and Riiser-Larsen seas. Another important goal for the bathymetry group was to support the other projects especially physical oceanography and marine geology by supplying informations on detailed morphological sea floor structures and updated working charts (Figure 2.11-1).

For physical oceanographers several mooring stations surveys were carried out to add necessary information on the ocean seafloor topography. The obtained depth and morphological information is an important prerequisite for the interpretation of current behaviour at mooring stations and fundamental for further station planning before deploying a new mooring. Therefore, collected data were visualized together with previously gathered data sets in large-scale charts and provided for planning activities.

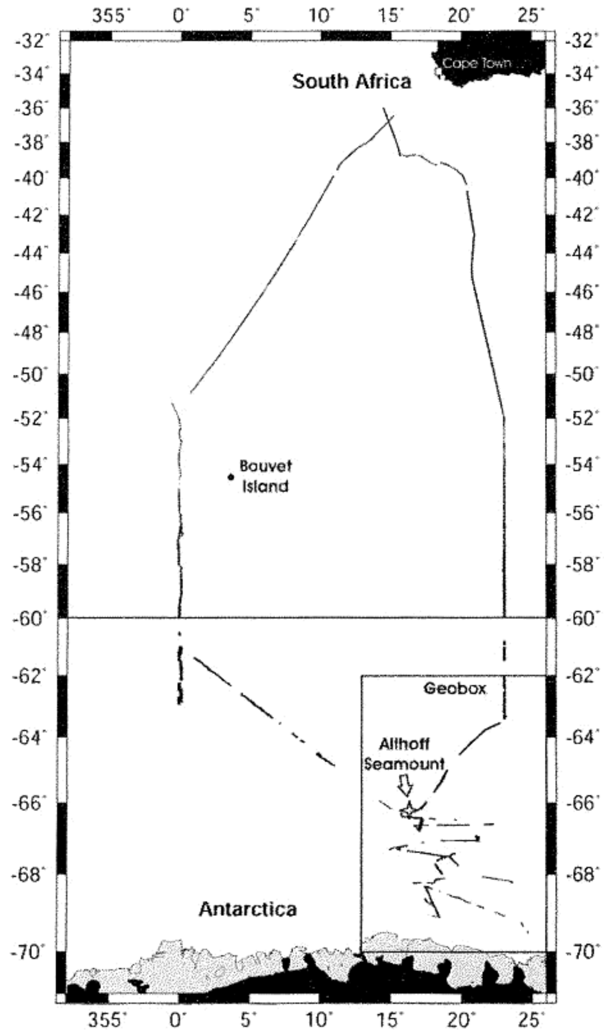

Figure 2.11-1: *Trackplot of the collected Hydrosweep data during ANT-XX/2*

The main area of geological interest during this expedition was the "GeoBox" covering the area between 62-70°S and 13-26°E. Within this area a channel system in the southern Riiser-Larsen Sea was main objective to "partly" systematic measurements. The spatial depth data collected with the swathsonar system were used to correlate with the information retrieved from the measurements by the sedimentsonar Parasound and to identify appropriate locations for sediment sampling. At these sites gravity corer and multicorer were deployed.

Finally all "partial" surveys of the Hydrosweep swathsonar system contributed to add more accurate data to the poor data density in the Southern Oceans and to enlarge the range of data available for international bathymetric charts such as the GEBCO (General Bathymetric Chart of the Oceans) and the AWI BCWS (Bathymetric Chart of the Weddell Sea).

Most of the measurements have - with respect to areal coverage - to be considered "partly or partially" because due to obligations by the German Federal Environmental Agency (UBA), the Hydrosweep system had to be shut down south of latitude 60°S when marine mammals (i.e. whales and seals) were identified or sighted within a range of 3 km around the vessel. Not before 20 minutes after the last sighting of a marine mammal, the Hydrosweep system could be re-started with a "soft start procedure" in order to avoid harming of marine mammals in the vicinity of the vessel, According to this "procedure", energy was increased over a time period of one hour until full measurements and data acquisition were possible.

Technically this "soft start procedure" was subdivided in three separate steps, each of them lasting for 20 minutes. With each step the emitted intensity was slowly increased. Step 1 was a shallow water search mode with a swath width of 200, Step 2 was a shallow water mode with a 1200 swath width and Step 3 was already a deep sea mode with 90° swath width but alternating directions. The full measurement mode of the system was reached not earlier than one hour and 20 minutes after the last sighting of a mammal.

Due to these obligations (and restrictions) south of 60°S profiling was very incomplete and as a result areal data coverage was poor as demonstrated at Althoff Seamount.

Earlier cruises in 1990 and 2000 discovered a rapidly changing seafloor and rough bottom topography in the waters at 66° to 66°30'S and 16° to 17°E. This led to the assumption of the existence of a larger seamount in that particular area. During ANT-XX/2, therefore, it was planned to carry out a more complete survey of these waters to get a better idea of extend, height and structural position of this feature. Approaching the area several whales were sighted and consequently the swath and sediment penetrating sonar systems (Hydrosweep and Parasound) had to be shut down. Only a single line crossing the structure could be obtained by the DWS echosounder revealing an approximate idea of the structure of this feature (Figure 2.11-2). However, for any more precise scientific interpretation a three dimensional spatial representation is needed, which can only be achieved by multibeam surveys. Nevertheless, by its general outline this feature was classified a seamount and named in April 2003 at a meeting of SCUFN (GEBCO Sub-Committee on Undersea Feature Names) "Althoff Seamount" after Friedrich Althoff (*19/2/1839 †20/10/1909). Althoff was a lawyer and later a Prussian politician for culture and science during the period of 1882-1907 with extraordinary efficacy. He was a professor for civil law before joining the Prussian Ministry for Culture where he became the director in 1897 Althoff was an active promoter or the expansion of German universities and scientific institutions. He focused his energy especially on the famous Valdivia expedition in 1899 which led into the southern Atlantic Ocean. During this expedition, among others, Bouvet Island was discovered.

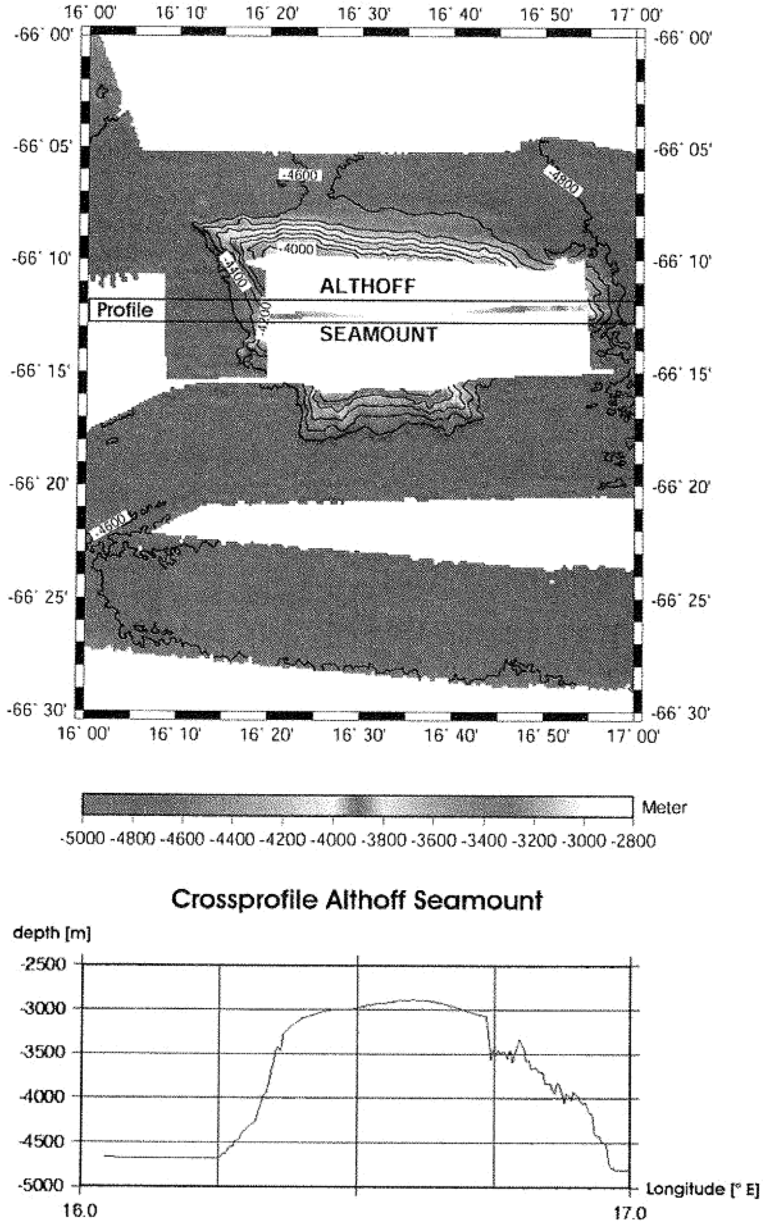

Figure 2.11-2: *Topographic map of the Althoff Seamount above and the crossprofile (bottom)*

2.11.2 Sediment characterization by echosounding and sampling

Gerd Kuhn, Sylvia Brückner, Claudia Didié, Matthias Forwick, Christian Hass, Norbert Lensch, Wolfgang Schmitt, Constanze v, Waldthausen and Thomas Wittling

The reconstruction of the paleoclimatic and paleoceanographic development of the late Quaternary Southern Ocean and adjacent continental areas in high temporal and spatial resolution is a main goal of our long-term study. During ANT-XX/2 the sedimentary budget of biogenic and terrigenous components and their variability was investigated in cooperation geochemical projects. Main objectives were the relationships between production of biogenic components and input of terrigenous components and involved nutrients. Therefore in addition to surface samples long sediment cores were recovered on the transects across the Polar Frontal Zone (Table 2.11-1) for the following projects:

- Establishment of a high resolution stratgraphy of the obtained sediment sectons (isotope stratigraphy, AMS-^{14}C age determinations, magnetic susceptibility),
- Quantification and reconstruction of terrigenous sediment supply and its distribution by paleocurrents (high-resolution granulometry, bulk and clay mineralogy, heavy minerals, geochemical tracers),
- Identification and quantification of biogenic and terrigenous components and their variation during glacial and interglacial, periods.
- Correlation of the marine sedimentary record with Antarctic ice core records and reconstruction of paleoenvironmental conditions.

The ship-mounted Parasound system (Krupp Atlas Electronics, Bremen, Germany) is a sub-bottom echosounder. It generates two primary sound waves at frequencies of 18 kHz and of 20.5-23.5 kHz. As a result of the parametric effect, a secondary frequency between 2.5 and 5.5 kHz is produced at a very narrow angle of 4°. This provides much higher horizontal resolution at a penetration depth comparable to that of other sediment-echosounding devices.

The Parasound device is attached to an analogue printer (Atlas DESO 25). The analogue signal is then digitised and post-processed using the PC-based Paradigma software (Spiess 1993). Digital data are stored on hard disk (later on CD) and printed simultaneously on a colour printer. Important data such as time, geographic position, and water depths are continuously plotted on a third printing device.

For geological work on board *POLARSTERN* the Parasound system is the most important tool. Stations for taking geological samples from the seafloor can only be planned properly with information based on Parasound data. The echosounding data recovered during transit between stations are also very important for marine geological work.

Therefore, the Parasound survey during ANT-XX/2 should cover the following goals and targets in addition to those relevant for the Riiser Larsen Sea:

- Mapping sediment distribution patterns along transects across the Polar Frontal Zone (areas of non deposition and high accumulation),
- To interpolate sediment budget and to identify transport processes of terrigenous and biogenic components to the seafloor during past climate periods,
- To identify areas showing sedimentary sequences of high temporal resolution,
- To provide information for the selection of locations for sediment coring (site surveys for future expeditions).

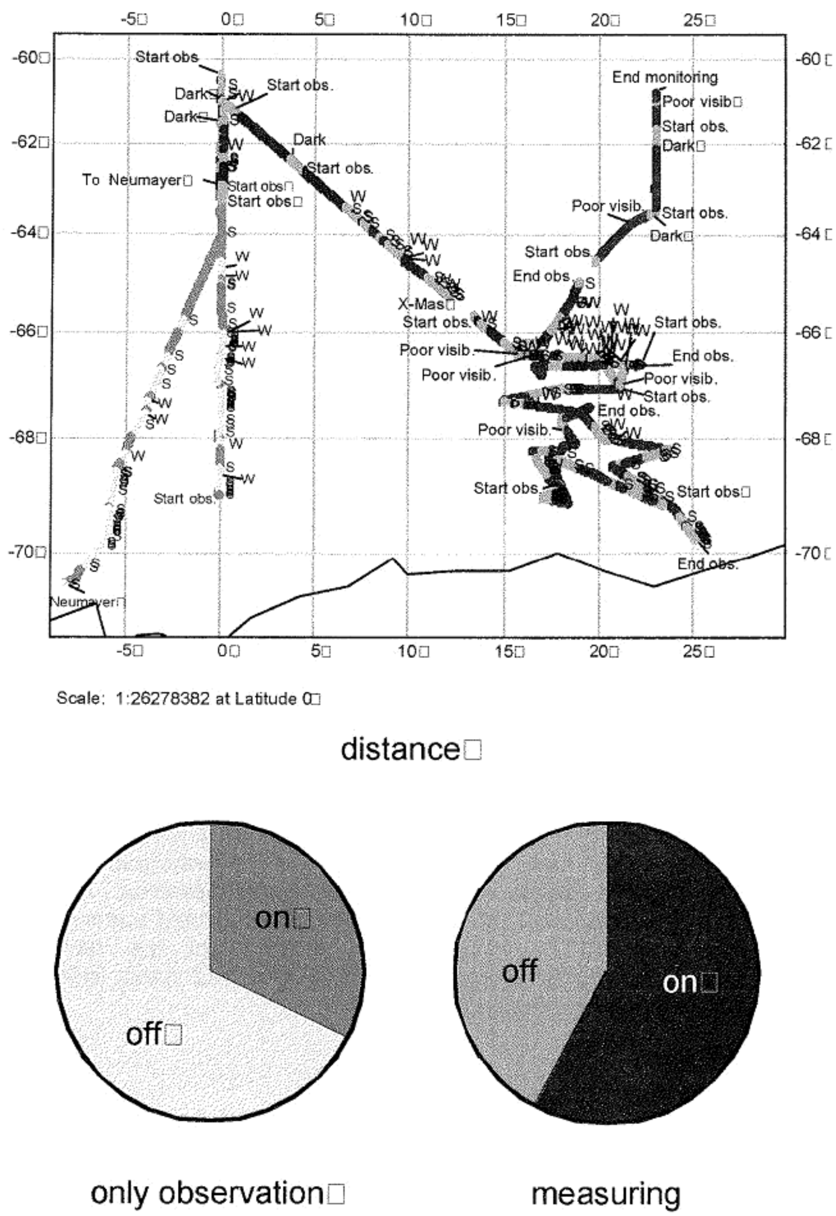

Figure 2.11-3: *Cruise track south of 60°S indicating distances with shutdown Hydrosweep and Parasound systems due to seals (S) or whales (W). The distance with measuring systems (black) was only 44% of total distance.*

In total 5400 nm of the cruise track were measured with the Parasound system. South of 60°S more then 50% of these targets could not been reached because of frequent shutdowns of the acoustic devices related to restrictive obligations by the German Environmental Agency (UBA) with respect to marine mammals protection. Furthermore, scientific interpretation of these data will be severely hampered by the frequent gaps in the data collection or will in many cases not be possible at all. Therefore, the collected profiles are of even less scientific value.

With operating Parasound system a total of 58% of the transit tracks were measured (Figure 2.11-3). Because of difficulties during operation and avoiding damage of the towed hydroacoustic mammal monitoring streamer, the Parasound system was switched off on the southern part of the Prime Meridian profile and during very heavy sea ice conditions. Therefore, south of 60°S altogether on only 44% of the total travel distance sediment acoustic data could be collected.

To minimize the acoustic emission the pulse length of the transmitted sound was selected to 2. This is equal to a very short pulse length of 0.5 ms at an operating frequency of 4 kHz. After shut down due to marine mammal observation the system was very slowly restarted 20 minutes after last sighting of a marine mammal. This procedure to slowly increase the emitted sound (Table 2.11-2) to scare away marine mammals took one hour and was conducted 98 times during ANT-XX/2 (equal to four days of potential profiling without any scientific data). This frequent on/off operation was very stressful for the system and ruined the inrush current limiter (which was bypassed later).

Many problems with the online inkjet printers and errors (wrong position or time and date) in the record headers of the digitised data occurred throughout the whole cruise. This has destroyed data and will make data processing a time consuming work. Therefore, an upgrade of the Parasound system (DS3) is absolutely needed. A software controlled start-up procedure and a software control of sound transmission should be inserted to reduce ping rate and sound emission.

Sites for sampling the seafloor were selected according to the Parasound data. All together 58 surface samples were collected with the Multicorer (MUC) or the Minicorer (MIC), the latter installed 20 m below the CTD (Table 2.11-1), a configuration that saved a couple of hours of station time. The water column at the hydrographic CTD stations was sampled for seawater stable isotope composition of dissolved inorganic carbon $\partial^{13}C_{DIC}$ and $\partial^{18}O$ at 43 stations (Table 2.11-3). With the collected surface samples the sediment composition will be mapped and material for the development of micropaleontological transfer functions and trace element and stable isotope analyses of benthic forams and ostracodes is available.

2.11.3 Physical properties of the sediment cores

Gerd Kuhn

Sediment cores were taken with a gravity corer (SL) and a piston corer (KOL) on 18 stations during the cruise (Table 2.11-1). Physical properties like sediment density, p-wave velocity, and magnetic susceptibility were measured on the collected sediment cores with a GEOTEK multi-sensor core logger (MSCL). For calculation of these values core diameter and temperature were measured in addition (Table 2.11-4).

For calibration the following parameter were used in the logger settings of the MSCL software (version 6) or afterwards:

- Temperature calibrated with Hg-thermometer:
  T = 0.003754 x -23.518995 R^2 = 0.99968
- Core thickness (displacement) with distance pieces
  D = 0.0019394 x 1.0001728 R^2 = 0.99979
- p-wave travel time with a water core of known temperature and theoretical sound velocity.
  offset for gravity corer (SL) 7.79 µs and for piston corer (KOL) 8.15 µs (Table 2.11-4)

- Gamma ray attenuation measurement and density calculation
  calculation with equation type $y = -Ax^2 + Bx + C$
  The coefficients A, B, and C were determined with measurements on calibration cores with defined density steps (GEOTEK calibration software) for the gravity corer with
  $y = 0.0001x^2 - 0.0682x + 10.126$, $R^2 = 0.9996$, and for the piston corer
  $y = 0.00002x^2 - 0.0595x + 10.049$, $R^2 = 0.9998$
  A and B, the linearity of the detector, were constant during the cruise. C, the sensitivity of the detector (I_O drift), was variable (Figure 2.11-4) and determined with a constant attenuation measurement (PVC-core) before each sediment core measurement. The values are stored in the calibration files for each core and the variability of In(Io) for the gravity corers (Figure 2.11-5) and piston corers (Figure 2.11-6) reached maximum -7% deviation (PS63/149-3).
- Magnetic susceptibility
  data were stored as sensor units and calculated for volume magnetic susceptibility (Table 2.11-4). Corrections for sensor drift during measurement and recalculation of core top and bottom data have been applied.
  Gravity corer sensor units times 6.391
  Piston corer sensor units times 14.584

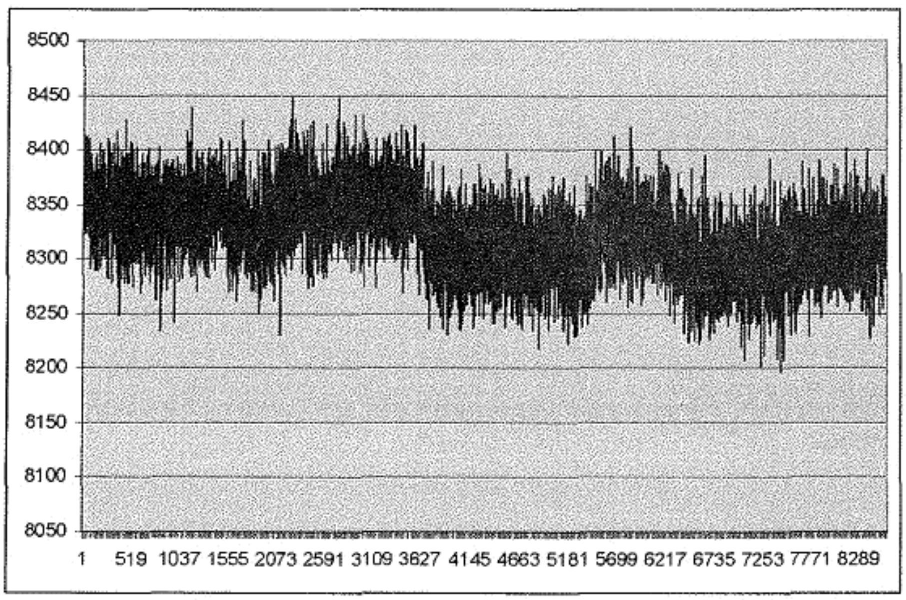

Figure 2.11-4: *Stability of the gamma-ray detector: counts over 23 hours*

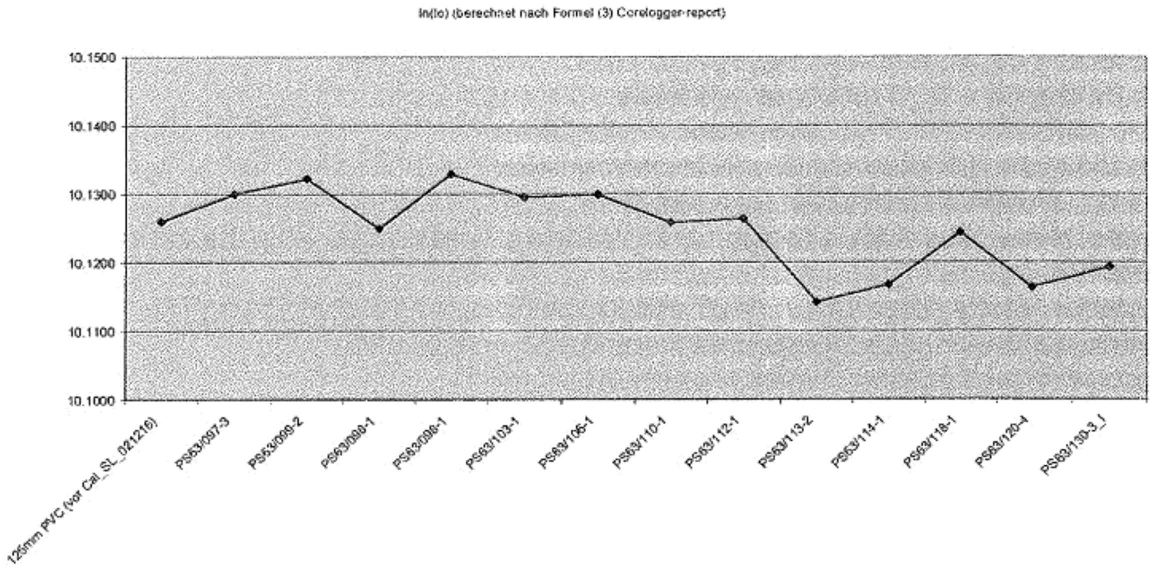

Figure 2.11-5: *Stability of the I_O-gamma attenuation measured during the cruise before measuring the gravity corer sediment cores.*

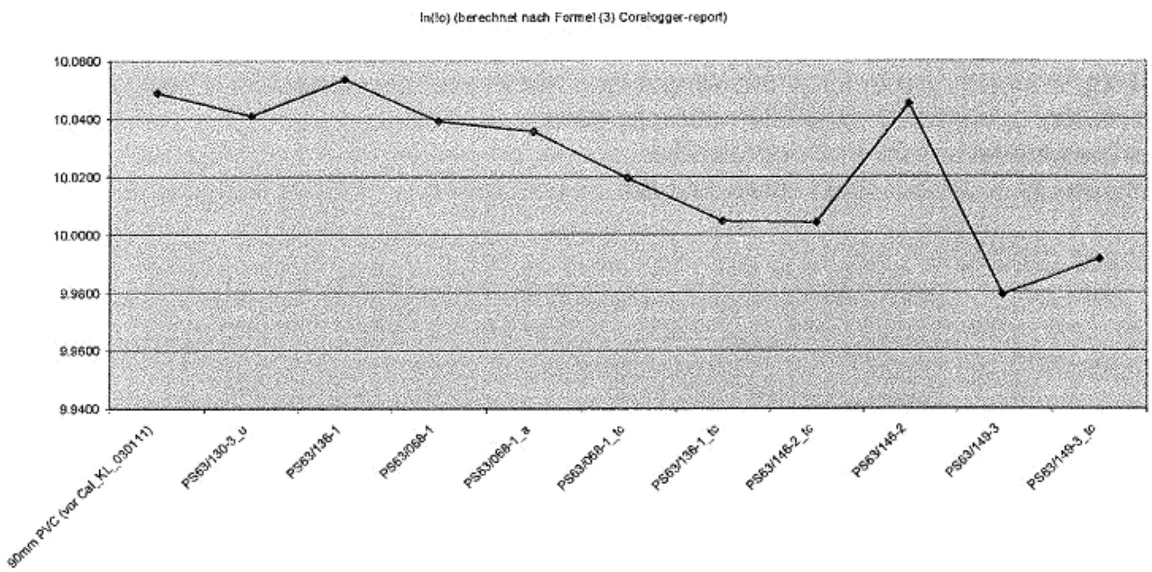

Figure 2.11-6: *Stability of the I_O-gamma attenuation measured during the cruise before measuring the piston corer sediment cores.*

All data were graphically controlled and bad values at core section boundaries were removed. The data will be stored in the database PANGAEA (www.pangaea.de).

First results and comparison with studied sediment cores showed nicely recorded cycles in magnetic susceptibility variations in core PS63/149-3. Low values are characteristic for warm climate periods (Holocene, marine isotope stage 5) with high accumulation of biogenic silicate. During cold climate periods accumulation of terrigenous material was higher and increases magnetic susceptibility values (Figure 2.11-7).

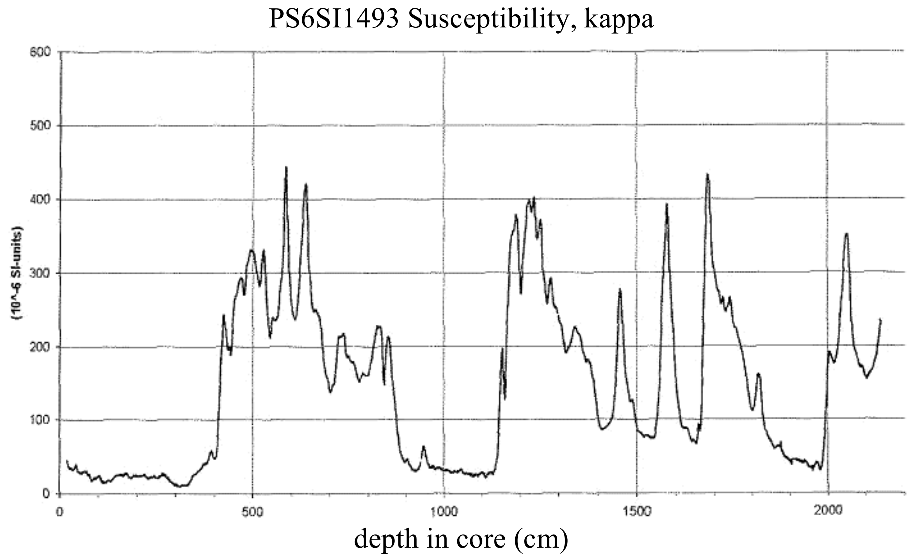

Figure 2.11-7: *Volume corrected magnetic susceptibility values from sediment core PS63/149-3.*

211.4 Dynamics of a channel-levee system in the Riiser Larsen Sea

Christian Hass

The goal of this part of the marine geological investigations includes the investigation of a broad system of channels and levees on the continental slope of the Riiser Larsen Sea. The major focus of the investigations is placed on mapping the working area in order to get an idea on the extent of this system. Channels form through dense water masses that flow down the continental slope. However, whether turbidity currents or colder and/or more saline waters than the ambient water masses form these dense waters are not known. Thus, the investigations aim at discovering the sources and reconstructing the principal processes that lead to channel formation in this area. A further goal is to investigate whether the channels are presently active pathways or whether they are old and/or pie-designed structures.

Levees frame the majority of the channels. Results from an earlier investigation (ANT-XVII/2) suggest adequate sediment accumulation rates for high-resolution climate reconstructions. Levee formation is closely linked to the processes that form the adjacent channels. Thus investigations of the levees provide also information on channel activity and its links to climate development.

Mapping was planned to be accomplished by Parasound sediment profiling the structure of the upper sediment layers and Hydrosweep swath sounding for bathymetry. Sediment samples were taken using a gravity corer (SL) and a multicorer (MUC).

Parasound profiling

The major goals and tasks of the Parasound surveys were:

- to provide information on the general acoustic characteristics of the sediments (sediment types). These include penetration, and structure of the sediment;
- to provide information on the horizontal extension of different sediment types and distinct reflectors in the sediment column;

- to provide information in order to aid selecting core locations (site surveys);
- to provide information on acoustic reflectors that shall be identified in sediment cores.
- to contribute to a mapping of the sediment characteristics of channels and related levees in the Rilser Larsen Sea.
- to classify sediment types that reveal information on sedimentation processes,
- to discover areas with sediments of high temporal resolution,
- to reconstruct and characterize pathways and processes of sediment-transport

Within the working area (western Riiser Larsen Sea) a total track of 2169 nm was accomplished in order to carry out Parasound profiling and Hydrosweep mapping. However, due to the restrictive obligations for the usage of hydroacoustic systems by the Federal German Environmental Agency (UBA) in order to protect marine mammals only a patchy fraction of the track could be measured. Only 969 nm - equivalent to only 45% the total track - were recorded by Parasound and Hydrosweep respectively; 1200 nm (55%) were not recorded (Figure 2.11-8). The sonar systems were shut down very irregularly, sometimes within a channel, on top of a levee or even right before a channel-levee structure. Thus in-depth investigations of sedimentary processes and structural features of channels and levees that require information on entire channellevee systems were largely prevented. The information gained from this survey is of only very limited use since propagation of sedimentary features across channel-levee systems could not be measured in the majority of the cases. Gaps in the profile lines may hide second- or third-order channels that may be small but that can significantly affect sedimentary processes if situated on levee flanks.

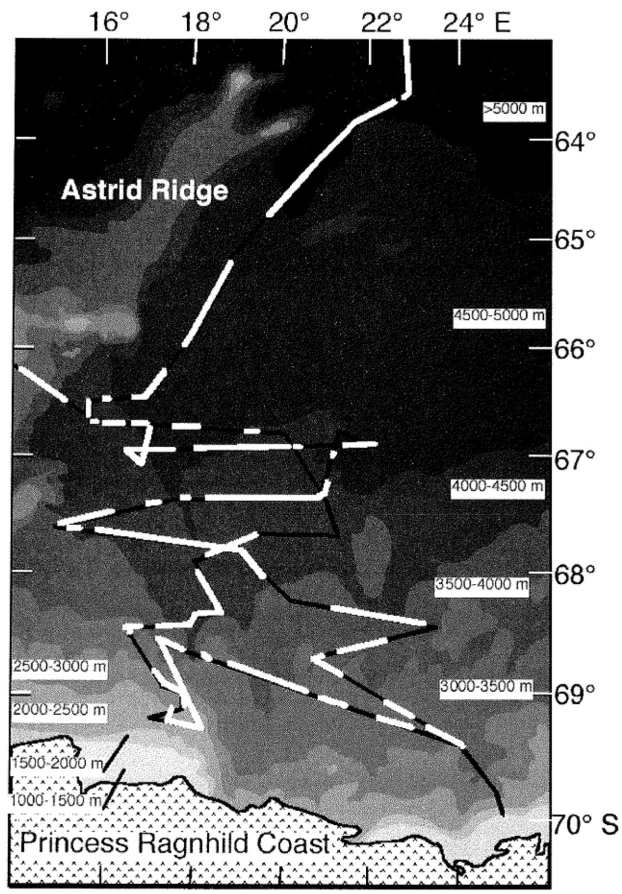

Figure 2.11-8: *Cruise track in the Riiser Larsen Sea where channel/levee systems should be mapped and the acoustic systems were shut down at 55% (dark lines).*

Despite the incomplete survey data the following results can be extracted: Channel/levee systems form the most common relief structure in this part of the Riiser Larsen Sea. The channels reveal typical structures with very low sound penetration suggesting hard and/or coarse-grained sediments. The western sides of the channels are usually flanked by levees that show up to 200 m of acoustically well-stratified sediments. Within the levees sometimes smaller, second or third-order channels form; building up smaller levees that sit on the large channel levees. Wherever possible the map of the working area that was worked out based on ANT-XVII/2 data (Thiede & Oerter 2002) was updated.

Sediment coring

The planning was to carry out a precise Parasound survey and then select core locations on the basis of that survey. Since the survey data were not reliable in terms of continuity due to the above-mentioned restrictions all but two positions had to be selected based on data of an earlier expedition (ANT-XVII/2; Thiede & Oerter 2002). During the ANT-XVII/2 expedition a number of important locations had already been sampled, thus, additional sediment cores taken during ANT-XX/2 must be rated of only less importance.

Long sediment cores (up to 13.8 m length) were taken using a gravity corer. The gravity corer includes a 2 t weight on the top and a variable number of steel pipes of 5 (3) m length each attached to the weight. Inside the steel pipes are plastic liners (12 cm Ø). Attached to the base of the gravity corer a core catcher is mounted that prevents the sediment core from sliding out of the plastic liners. Once recovered, the 5 (3 m) m plastic liners were cut into 1 m pieces. Subsequently the 1 m pieces were logged using a multisensor core logger. Undisturbed surface samples were recovered using a multicorer equipped with 12 tubes (6 cm Ø, 60 cm tube length). Multicorer lengths were usually around 30 cm. On every geological station within the working area gravity corer and multicorer were deployed.

Due to time consuming marine-mammal-watches related to the Parasound and Hydrosweep profiling projects, opening of the sediment cores, core descriptions, sampling, X-radiography, colour scans, photographs, and further analyses could not be carried out on board.

A total of 17 locations within the working area were sampled (Figure 2.11-9). Two locations were selected upon new Parasound data, 13 stations were selected on the basis of ANT-XVII/2 data, three stations were sampled upon occasion at a CTD station and during transit.

Nine inner-channel locations were sampled. In every case the surface sediments consisted of very soft silty clay and could easily be cored using the multicorer. However, the gravity corer was not able to penetrate deeper than two meters. On five mid-channel locations the gravity corer was recovered empty suggesting that physically very hard sub-surface sediments prevented penetration. On one of these locations the damaged core catcher visibly released a small amount of sediment (i.e. all of the approx. 30-50 cm of sediment that made it up to the sea surface) when the corer came out of the water. Three of the mid-channel locations allowed to recover 147, 148, and 94 cm, respectively, of the sediment column (PS63/099-2, 105-2, 114-1). At two of these locations the coring gear was severely damaged. Cores PS63/099-2 and PS63/105-2 obviously got stuck in very dense and water depleted sediments that included larger stones (several cm Ø) in a yellowish silty-clayey matrix. These sediments significantly differed from all sediments cored in the Riiser Larsen Sea; it is presumably much older than the overlying softer sediments. Core PS63/114-1 went undamaged back on deck but revealed only 147 cm of sediment. The corer was obviously not able to penetrate a convolutedly bedded coarse-sand layer that occurred at the base of the recovered core. One of the cores (PS63/120-4) was taken on transit from the lower northern area of the western channel. It revealed 427 cm of soft sediments. Since the Parasound system had to be shut down no information on the position of this core location relative to the channel axis could be gained.

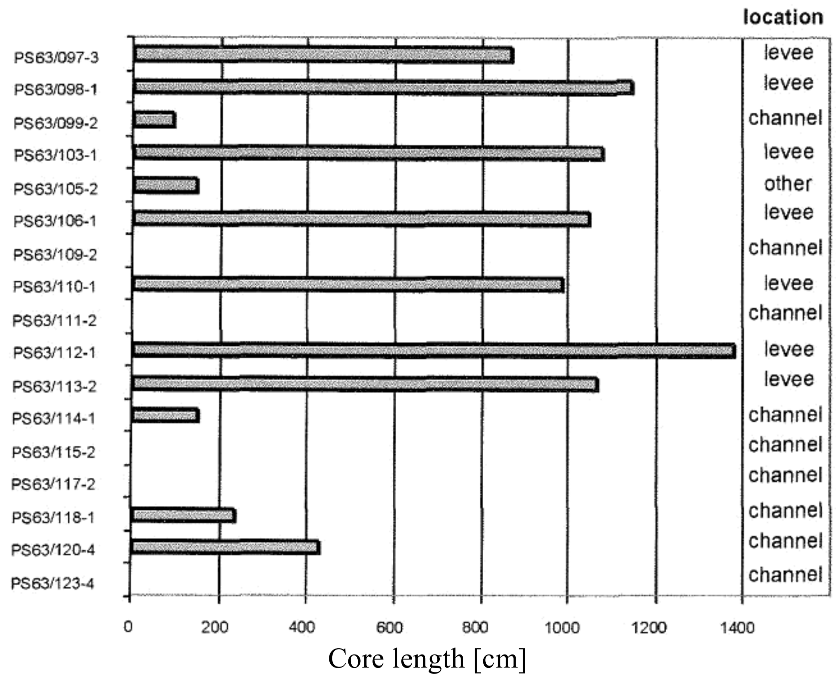

Figure 2.11-9: *Core recovery and length in the Riiser Larsen Sea in relation to location.*

References

Thiede, U. & Oerter, H. (2002): The expedition ANTARKTIS XVII/2 of the Research Vessel *POLARSTERN* in 2000.- Rep. Polar Marine Res. 404, 1-245.

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Table 2.11 -1: *List of surface sediment samples and sediment cores from ANT-XX/2.*

Station PS63/	Date	Time (UTC)	Water depth (m)	LatidudeLongit. (S)	GEAR	Recov. (cm)	Penetr. (cm)	Remarks	Location
024-1	28.11.2002	16:06	4562	47°01.46' 04°52.85'E	MIC	23			Cape Basin
025-1	29.11.2002	11:06	4086	49°00.12' 02°50.41'E	MIC			empty	Cape Basin
026-2	29.11.2002	22:59	3918	50°15.00' 01°25.28'E	MIC	<3			SW-Ind. Ridge
027-2	30.11.2002	7:43	1342	51°00.20' 00°31.31'E	MUC	10			SW-Ind. Ridge
028-2	01.12.2002	1:12	3011	52°01.18' 00°06.07'W	MUC	35			SW-Ind. Ridge
030-3	01.12.2002	20:56	2581	52°59.55' 00°01.47'E	MUC	13			SW-Ind. Ridge
032-2	03.12.2002	6.53	2764	54°00.36' 00°06.56'W	MUC	30			SW-Ind. Ridge
033-5	03.12.2002	16:42	1632	54°31.24' 00°00.44'W	MUC	20			SW-Ind. Ridge
035-2	04.02.2002	4:53	3427	55°29.45' 00°05.47'W	MUC	20			SW-Ind. Ridge
037-4	05.12.2002	2:45	3334	55°55.62' 00°05.92'E	MUC	24			SW-Ind. Ridge
033-2	05.12.2002	6:54	4352	56°31.33' 00°03.32'W	MUC	33			SW-Ind. Ridge
039-2	05.12.2002	18:39	4018	57°31.38' 00°07.83'W	MUC			Not released	SW-Ind. Ridge
039-3	05.12.2002	20.19	3989	57°31.64' 00°07.37'W	MUC	32			SW-Ind. Ridge
041-2	06.12.2002	6:35	3839	58°28.89' 00°05.01'E	MUC	33			SW-Ind. Ridge
042-4	07.12.2002	3:15	4667	59°02.70' 00°04.17'E	MUC	41			SW-Ind. Ridge
043-2	07.12.2002	15:36	4580	59°27.92' 00°00.39'W	MUC	36			SW-Ind. Ridge
047-2	08.12.2002	15:06	5423	60°58.36' 00°00.54'W	MUC	37			N Weddell Sea
049-2	09.12 2002	6:51	5383	62°01.29' 00°03.61'W	MUC	12			N Weddell Sea
052-2	09.12.2002	22:17	5310	63°00.13' 00°05.50'W	MUC	10			N Weddell Sea
054-5	10.12.2002	23.14	5164	64°00.37' 00°01.15'E	MUC	9			N Weddell Sea
057-2	16.12.2002	21:34	4220	68°30.67' 00°00.92'W	MUC	35			N Weddell Sea
059-2	17.12.2002	10:25	4588	67°29.22' 00°00.48'E	MUC	32			N Weddell Sea
061-3	18.12.2002	2:12	4500	66°30.42' 00°00.01'E	MUC	26			N Weddell Sea
064-6	19.12.2002	17:43	3698	64°59.65' 00°02.70'E	MIC	22			Maid Rise
068-1	25.12.2002	21:48	5427	61°00.27' 00°00.81'E	KOL/25	1924	2100	TC=88cm	N Weddell Sea
071-1	21.12.2002	12:31	5375	61°46.75' 02°04.50'E	MIC	17			N Weddell Sea
073-1	22.12.2002	1:43	5345	62°33.16' 04°12.18'E	MIC	12			Enderby Basin
076-2	22.12.2002	14:50	5330	63°17.63' 06°17.18'E	MUC	37			Enderby Basin
078-1	23.12.2002	7:36	5190	64°06.85' 08°38.54'E	MIC	24			Enderby Basin
080-1	23.12.2002	22:20	5213	64°33.70' 09°48.22'E	MIC	24			Enderby Basin
081-3	24.12.2002	7:29	4804	64°53.34' 10°56.62'E	MUC	36			Astrid Ridge
082-2	24.12.2002	15:18	4111	65°16.84' 12°11.85'E	MUC	37			Astrid Ridge
083-2	25.12.2002	10:09	2612	65°40.29' 13°21.55'E	MUC	16			Astrid Ridge
095-1	30.12.2002	12:00	1169	69°53.10' 25°14.00'E	MIC	13			Riiser Larsen Sea
095-3	30.12.2002	17:12	1140	69°53.34' 25°12.75'E	MUC	8			Riiser Larsen Sea
097-1	01.01.2003	8:46	3130	68°57.56' 17°34.37'E	GKG			failed	Riiser Larsen Sea
097-2	01.01.2003	10:41	3046	68°57.85' 17°35.91'E	MUC	37			Riiser Larsen Sea
097-3	01.01.2003	12:16	3068	68°57.71' 17°35.57'E	SL/10m	872	1050		Riiser Larsen Sea
098-1	01.01.2003	14:30	2914	68°57.82' 17°41.55'E	SL/l5m	1148	1300		Riiser Larsen Sea
098-2	01.01.2003	16:04	2868	68°58.32' 17°41.87'E	MUC	36			Riiser Larsen Sea
099-1	01.01.2003	18:25	3625	68°59.25' 18°00.52'E	MUC	36			Riiser Larsen Sea
099-2	01.01.2003	20:00	3627	68°59.26' 18°00.62'E	SL/10m	94	100	damaged	Riiser Larsen Sea
103-1	02.01.2003	12:48	3590	68°13.14' 16°44.67'E	SL/15m	1080	1400		Riiser Larsen Sea
103-2	02.01.2003	14:24	3587	68°13.23' 16°44.32'E	MUC	37			Riiser Larsen Sea
105-1	02.01.2003	23:59	4350	68°08.08' 18°12.37'E	MUC	36			Riiser Larsen Sea
105-2	03.01.2003	1:45	4351	68°07.97' 18°12.78'E	SL/15m	147	200	damaged	Riiser Larsen Sea
106-1	03.01.2003	5:10	3754	68°06.26' 18°49.14'E	SL/15m	1048	1200		Riiser Larsen Sea
106-2	03.01.2003	6:43	3749	68°06.20' 18°49.05'E	MUC	37			Riiser Larsen Sea
109-1	03.01.2003	18:24	4494	67°24.04' 19°36.64'E	MUC	36			Riiser Larsen Sea
109-2	03.01.2003	20.10	4489	67°25.06' 19°36.73'E	SL/5m	cc-sample	0	failed	Riiser Larsen Sea
110-1	04.01.2003	0:23	4230	67°25.06' 20°40.82'E	SL/15m	991	1550		Riiser Larsen Sea
110-2	04.01.2003	2:11	4235	67°25.06' 20°49.14'E	MUC	30			Riiser Larsen Sea
111-1	04.01.2003	5:52	4517	67°25.69' 21°31.33'E	MUC	35			Riiser Larsen Sea
111-2	04.01.2003	7:39	4509	67°25.69' 21°31.40'E	SL/3m	0	0	failed	Riiser Larsen Sea
112-1	04.01.2003	1:36	4480	67°04.97' 21°06.29'E	SL/15m	1380	1550		Riiser Larsen Sea

Station PS63/	Date	Time (UTC)	Water depth (m)	LatidudeLongit. (S)	GEAR	Recov. (cm)	Penetr. (cm)	Remarks	Location
112-4	04.01.2003	13:57	4482	67°04.92' 21°06.22'E	MUC	38			Riiser Larsen Sea
113-1	04.01.2003	19:26	4459	66°28.52' 21°30.61'E	MUC	35			Riiser Larsen Sea
113-2	04.01.2003	21:16	4457	66°28.50' 21°30.76'E	SL/15m	1068	1500		Riiser Larsen Sea
114-1	05.01.2003	0:40	4706	66°35.71' 22°05.32'E	SL/3m	148	200		Riiser Larsen Sea
114-2	05.01.2003	2:33	4697	66°35.71' 22°05.03'E	MUC	37			Riiser Larsen Sea
115-1	05.01.2003	5:17	4744	66°37.71' 22°15.64'E	MUC	21			Riiser Larsen Sea
115-2	05.01.2003	7:06	4735	66°37.69' 22°13.30'E	SL/3m	0	0	failed	Riiser Larsen Sea
117-1	06.01.2003	2:00	4737	66°27.02' 17°10.76'E	MUC	36			Riiser Larsen Sea
117-2	06.01.2003	3:52	4733	66°27.06' 17°10.79'E	SL/3m	0	100	failed	Riiser Larsen Sea
116-1	06.01.2003	8:37	4347	66°24.17' 15°48.27'E	SL/15m	235	500	damaged	Riiser Larsen Sea
118-2	06.01.2003	10:21	4355	66°24.15' 15°48.34'E	MUC	12			Riiser Larsen Sea
120-3	07.01.2003	3:16	4890	66°24.46' 18°29.43'E	MUC	40			Riiser Larsen Sea
120-4	07.01.2003	5:18	4890	65°24.34' 18°29.04'E	SL/5m	427	550		Riiser Larsen Sea
121-2	07.01.2003	11:25	4977	64°57.43' 19°01.22'E	MIC	25			Riiser Larsen Sea
123-3	08.01.2003	10:11	5017	64°08.10' 20°45.44'E	MUC	39			Riiser Larsen Sea
123-4	08.01.2003	12:12	5010	64°08.16' 20°45.30'E	SL/8m	0	0	failed	Riiser Larsen Sea
126-2	09.01.2003	7:59	5089	62°59.56' 22°58.88'E	SL/5m	0	0	failed	Enderby Basin
126-3	09.01.2003	9:55	5108	62°59.66' 22°58.01'E	MUC	40			Enderby Basin
130-2	10.01.2003	5:18	5181	61°29.97' 23°00.05'E	MUC	37			Enderby Basin
130-3	10.01.2003	7:20	5131	61°29.84' 22°59.76'E	SL/10m	1136	1200		Enderby Basin
132-1	10.01.2003	17:10	5210	60°53.61' 22°59.98'E	KOL/25			aborted	Enderby Basin
135-2	11.01.2003	12:31	4825	59°29.97' 23°00.53'E	MUC			empty	Enderby Basin
136-1	11.01.2003	17:06	5375	59°19.26' 22°59.54'E	KOL/25	1640	1700	Damaged TC=85cm	Enderby Basin
136-2	11.01.2003	20:13	5388	59°19.43' 22°59.56'E	MUC	29			Enderby Basin
139-1	12.01.2003	11:55	5370	58°18.84' 22°59.76'E	KOL/20		empty	released	EnderbyBasin
139-2	12.01.2033	14:35	5368	58°17.97' 23°00.05'E	MUC	33			Enderby Basin
139-3	12.01.2003	17:36	5379	58°17.79' 22°59.86'E	KOL/20		empty	Released at 5200m	Enderby Basin
141-2	13.01.2003	7:12	5412	57°30.91' 22°59.06'E	MUC	26			Enderby Basin
143-2	13.01.2003	20:14	4810	56°30.43' 23°00.85'E	MUC	35			Enderby Basin
146-1	14.01.2003	10:36	4733	55°19.24' 23°00.01'E	MUC	32			Enderby Basin
146-2	14.01.2003	13:16	4730	55°19.26' 23°00.03'E	KOL/20	1782	2100	TC=43cm	Enderby Basin
149-2	15.01.2003	6:08	3804	53°57.25' 23°02.86'E	MUC	31			SW-Ind. Ridge
149-3	15.01.2003	8:43	3805	53°57.32' 23°02.87'E	KOL/25	2119	2400	TC=65cm	SW-Ind. Ridge

Table 2.11-2 *Softstart parameter settings of the Parasound system.*

Minutes startup	Channel Select	Gain	Mode	Angle	Pulse Length
0	NBS	1	1	20	1
10	NBS	10	1	20	1
20	NBS	100	1	20	1
30	PAR/NBS	100	1	20	1
40	PAR/NBS	100	4	20	1
50	PAR/NBS	100	4	4	1
60	PAR/NBS	100	4	4	2

Table 2.11-3: *List of CTD/rosette water sampler, sampled for seawater stable isotope composition.*

Station	Gear	Lat. S	Long.	waterdepth, Pmax or. HS	
PS63/024-1	CTD	47°01.46'	04°52.85'E	4625	0°-Transect
PS63/032-1	CTD	54°00.13'	00°06.42'W	2683	
PS63/033-4	CTD	54°31.47'	00°00.24'W	1565	
PS63/037-3	CTD	56°56.46'	00°04.96'E	3720	
PS63/041-3	CTD	58°28.68'	00°05.77'E	3832	
PS63/043-1	CTD	59°28.65'	00°01.74'W	4628	
PS63/047-1	CTD	60°59.26'	00°02.86'W	5460	
PS63/052-1	CTD	63°00.08'	00°04.87'W	5370	
PS63/057-1	CTD	68°30.36'	00°00.77'W	4300	
PS63/061-4	CTD	66°30.59'	00°00.04'E	4570	
PS63/076-3	CTD	63°17.64'	06°17.18'E	5330	NW-SE-Transect
PS63/081-2	CTD	64°53.15'	10°57.54'E	4913	
PS63/082-1	CTD	65°16.90'	12°09.57'E	4145	
PS63/083-1	CTD	65°40.14'	13°21.22'E	2660	
PS63/087-1	CTD	66°27.51'	17°38.36'E	4870	GeoBox South
PS63/090-1	CTD	67°59.48'	20°15.17'E	4052	
PS63/093-1	CTD	69°15.16'	24°08.95'E	3267	
PS63/095-1	CTD	69°53.10'	25°14.00'E	1176	
PS63/100-1	CTD	69°13.53'	17°57.86'E	2508	
PS63/101-1	CTD	68°49.38'	17°59.27'E	3700	
PS63/104-1	CTD	68°14.46'	17°59.82'E	4314	
PS63/107-2	CTD	67°39.63'	17°59.92'E	4566	
PS63/116-1	CTD	66°48.06'	16°59.51'E	4707	
PS63/120-2	CTD	65°24.42'	18°29.45'E	4985	GeoBox North
PS63/124-1	CTD	63°44.70'	21°44.10'E	5145	
PS63/125-1	CTD	63°30.07'	22°59.56'E	5166	23°E-Transect
PS63/126-1	CTD	62°59.78'	22°59.27'E	5196	
PS63/127-1	CTD	62°29.93'	23°00.06'E	5222	
PS63/131-1	CTD	60°59.90'	22°59.92'E	5272	
PS63/133-1	CTD	60°30.00'	23°01.18'E	5163	
PS63/134-1	CTD	59°57.66'	22°59.65'E	5034	
PS63/135-1	CTD	59°29.94'	23°00.76'E	4900	
PS63/140-1	CTD	58°00.93'	22°59.56'E	5303	
PS63/141-1	CTD	57°30.35'	22°59.78'E	5250	
PS63/142-1	CTD	57°00.58'	22°59.65'E	4717	
PS63/143-1	CTD	56°30.25'	23°00.40'E	4880	
PS63/144-1	CTD	56°00.23'	22°59.90'E	3736	
PS63/145-1	CTD	55°30.37'	23°00.91'E	4358	
PS63/147-1	CTD	55°00.59'	23°00.40'E	4534	
PS63/148-1	CTD	54°30.18'	22°59.85'E	3567	
PS63/149-1	CTD	53°57.01'	23°02.99'E	3857	
PS63/150-1	CTD	53°29.42'	23°00.20'E	3123	
PS63/152-1	CTD	52°59.90'	22°59.54'E	1942	

Table 2.11-4: *Sensors and parameter settings for measurements with the GEOTEK multi-sensor core logger.*

P-Wellengeschwindigkeit und Kerndurchmesser
  Platten-Transducer-Durchmesser: 4 cm
  Transmitter Pulsfrequenz: 500 kHz
  Pulswiederholungsrate: 1 kHz
  registrierte Pulsauflösung: 50 ns
  gate: 2800
  delay: 10 Ls
  P-Wellenlaufzeit offset: 7.79 Ls (SL, 2*2.5 mm Wandstarke), 8.15 Ls (KOL, 2*2.7 mm Wandstärke)
  Temperature = 20°C, Salinity = 35 psu, not corrected for water depth and in situ temperature.

Temperatur
  Bimetall Sensor

Density
  Gammastrahlenquelle: Cs-137
  Aktivität: 356 MBq
  Energie: 0.662 MeV
  Blendendurchmesser: 5.0 mm (SL+KOL)
  Gammastrahlendetektor: Gammasearch2, Modell SD302D, Ser. Nr. 3047 , John Caunt Scientific Ltd., 10 s Zählzeit

Fractional porosity
  Mineral grain density = 2.75, water density 1.026

Magnetische Susceptibilität
  Spulensensor: BARTINGTON MS-2C, Ser. Nr. 208 (SL+KOL)
  nominaler Spuleninnendurchmesser: 14 cm
  Spulendurchmesser: 14.8 cm
  Wechselfeldfrequenz: 565 Hz, Zählzeit 10 s, Präzision 0.1 * 10^{-5} (SI)
  Magnetische Feldstärke: ca. 80 A/m RMS
  Krel: 1.56 (SL, 12 cm Kern-ø), 0.69 (KOL, 8.46 cm Kern-ø)
  Spulensensorkorrekturfaktor 6.391 (SL) 14.584 (KOL) für 10^{-6} (SI)

Dickenmessung
  Penny + Giles, Type HLP 190..., Ser.#.Nr. 92730147

2.115 SYNPART Synoptical investigation of the particle flux in the eastern Weddell Gyre

Walter Geibert, Claudia Hanfland and Regina Usbeck

The starting hypothesis for this study was that in the Eastern Weddell Gyre between 0°E and 35°E, a hitherto overlooked region of high productivity, would be found. This assumption was supported by model results derived from nutrient budgets (Usbeck 1999, Usbeck et al. 2002), data of whale abundance (Tynan 1998) as well as by other data from adjacent areas. Satellite data of surface chlorophyll do not show a pronounced anomaly at that region, and a further question was whether such a high productivity region could be overlooked by the satellites due to deep chlorophyll. However, hydrographical and geochemical data from the region of interest itself were extremely sparse. Therefore, a study was initiated which should allow to get an impression of the particle flux. Real-time SEAWIFS-satellite images of the region would allow comparing on-site measurements with remote sensing data. Chlorophyll profiles were measured in order to compare deep and surface chlorophyll, as well as to get a general idea of phytoplankton activity in the region. Oxygen was measured onboard on all CTD profiles, and nutrient samples were taken for later analysis in the home laboratory. ^{234}Th was measured on depth profiles in order to get estimates of export productivity. Surface sediment samples were taken in order to determine accumulation rates when back in the home lab. Thus, an impression of particle flux throughout the whole water column could be obtained.

Satellite images

The SEAWIFS chlorophyll data for the region show a larger bloom for the eastern part of the Weddell Gyre than in previous years. So far, the results agree with chlorophyll measurements. However, the absolute chlorophyll concentrations given by SEAWIFS for the bloom in the eastern Weddell Gyre do not at all reflect the absolute values obtained by in-situ chlorophyll measurements Whereas satellite data give surface values of 2 µg/l in the eastern Weddell Gyre, yet uncalibrated in-situ fluorometer values are substantially higher (5-15 µg/l), and only part of this discrepancy can be explained by the deep chlorophyll maxima. As there had been very few chlorophyll profiles from the Southern Hemisphere available for calibration of the SEAWIFS data, it seems reasonable to assume that remote sensing data are substantially underestimating the productivity of the Weddell Gyre. However, the calibration of the fluorometer has to be awaited before final conclusions are drawn.

Chlorophyll

A seapoint fluorometer was deployed with all CTD stations (Figure 2.11-10), except a few in the beginning of the cruise. Additionally, about 150 samples were taken from the CTD bottles for later analysis of pigment concentration, which will allow to calibrate the fluorometer measurements of chlorophyll-a (Chl-a). Three transects of chlorophyll-a were obtained, one N-S at 0°E from about 52°S to the Antarctic coastline (Figure 2.11-11a), one with NW-SE orientation from about 0°E, 64°S to 23°E, 70°S (Figure 2.11-11b) and a further S-N transect, mostly at 23°E (Figure 2.11-11c), covering the core of the region of interest.

The three sections shown below (Figure 2.11-11a-c) illustrate that the Weddell Gyre is in general much more productive than could be derived from satellite images. Whereas the blooms in the ACC reach about 2 µg/l Chl-a (all values uncalibrated) and are relatively homogeneous with depth, the profiles in the Weddell Gyre are typically much lower at the sea surface but reach Chl-a concentrations up to 15 µg/l. In the eastern Weddell Gyre, extremely high values of Chl-a were found, sometimes exceeding the fluorometer's range (up to 15 µg/l). Maxima were typically between 7 and 15 µg/l in the eastern Weddell Gyre from about 62.5 to 55°S. These values fully support the starting hypothesis, revealing a huge area of high productivity just where predicted by model results. For final results, the calibration of the fluorometer has to be awaited.

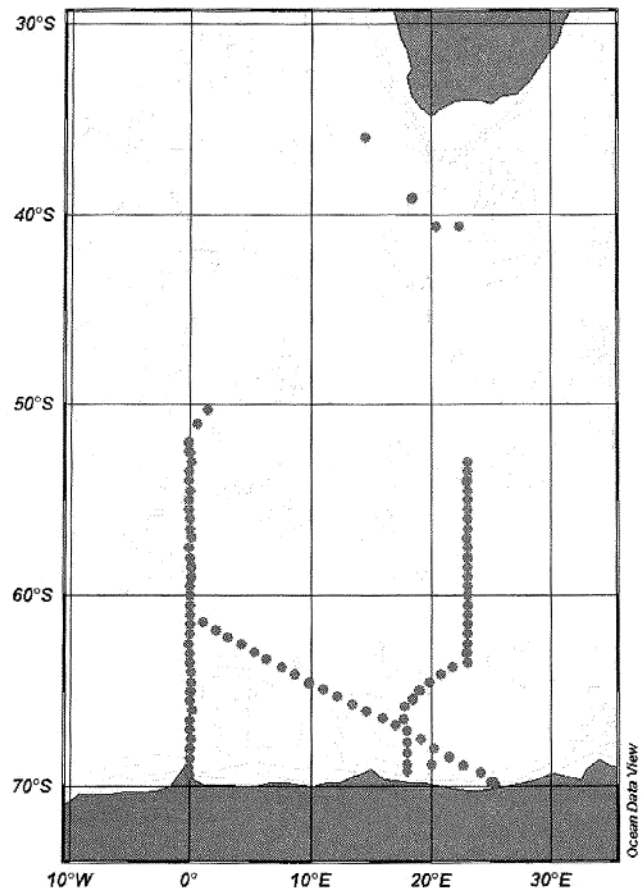

Figure 2.11-10: *Locations of all CTD-depth profiles including fluorometric determination of chlorophyll a.*

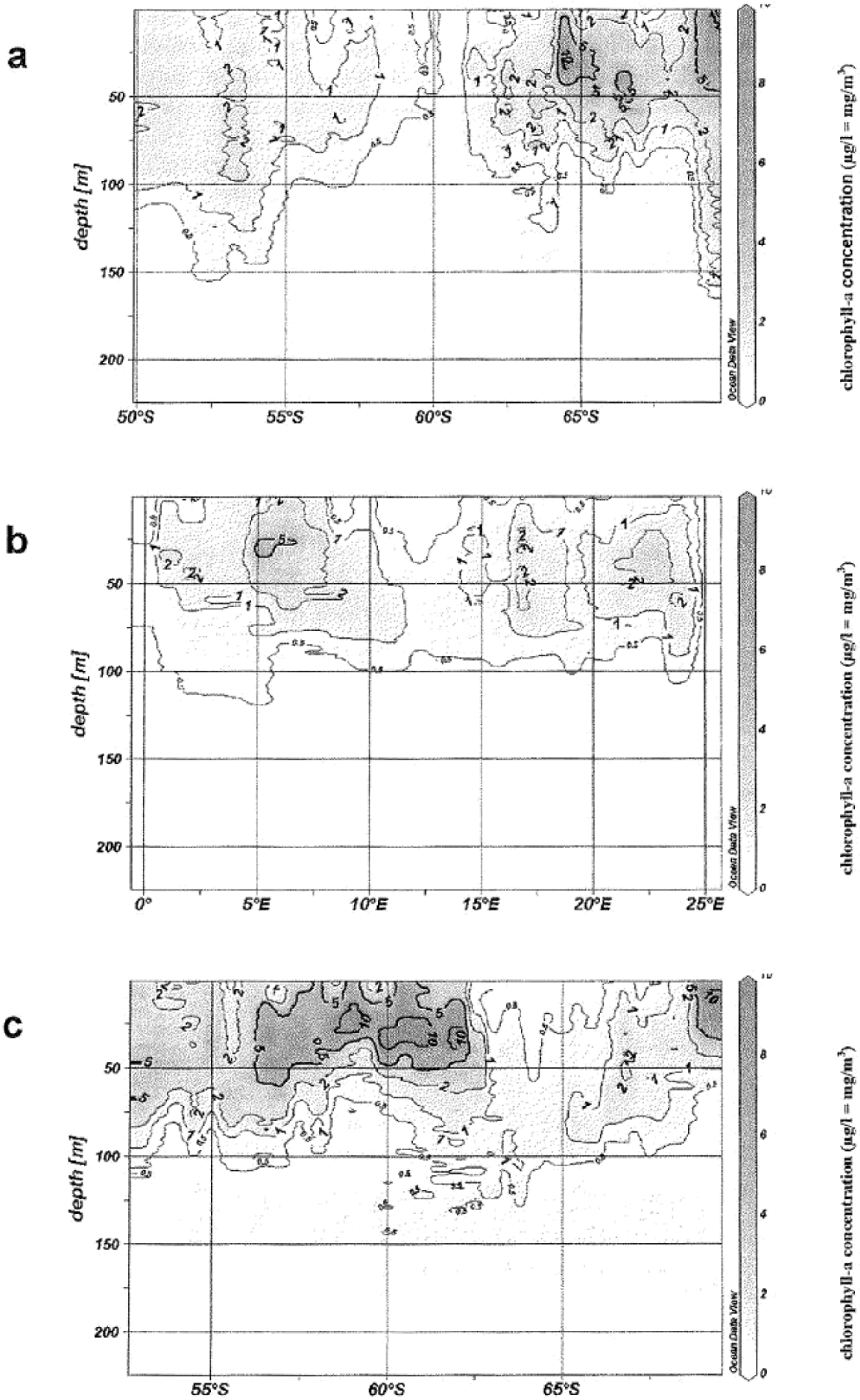

Figure 2.11-11: *Concentration of chlorophyll a (fluorometrically, yet uncalibrated) vs. depth.*
a: N-S transect along 0°E,
b: NW-SE-transect,
c: N-S transect along 23°E (see Figure 2.11-9 for details).

Thorium-234

^{234}Th (half-life 24.1 days) is a naturally occurring radionuclide that originates from the ^{238}U decay chain. It is very particle reactive, and with increasing particle concentration an increasing part of ^{234}Th is found on particles. Recent observations sugest that acid polysaccharides, a product of phytoplankton, are the main adsorber for ^{234}Th in natural seawater (Quigley et al. 2002) Generally spoken, the fraction of ^{234}Th found on particles may be considered a measure for biogenic particle concentration under open ocean conditions.

When particles sink out of the euphotic zone, they carry ^{234}Th with them. Consequently, particle export leads to an export of ^{234}Th, too. As the activity of ^{234}Th is in equilibrium with ^{238}U when no export takes place, the disequilibrium between ^{238}U and ^{234}Th is a measure for particle export (Coale & Bruland 1985).

In order to get information on carbon export, 25 vertical profiles of ^{234}Th from the upper water column were measured (Figure 2.11-12) as described in Usbeck et al. (2002). Preliminary results show a good agreement with the chlorophyll data. High fractions of Th on particles are found in regions with high chlorophyll concentrations. On the eastern transect, a strong depletion of Th was found that can be explained by particle export. The subsurface maximum of chlorophyll is often reflected in particulate ^{234}Th.

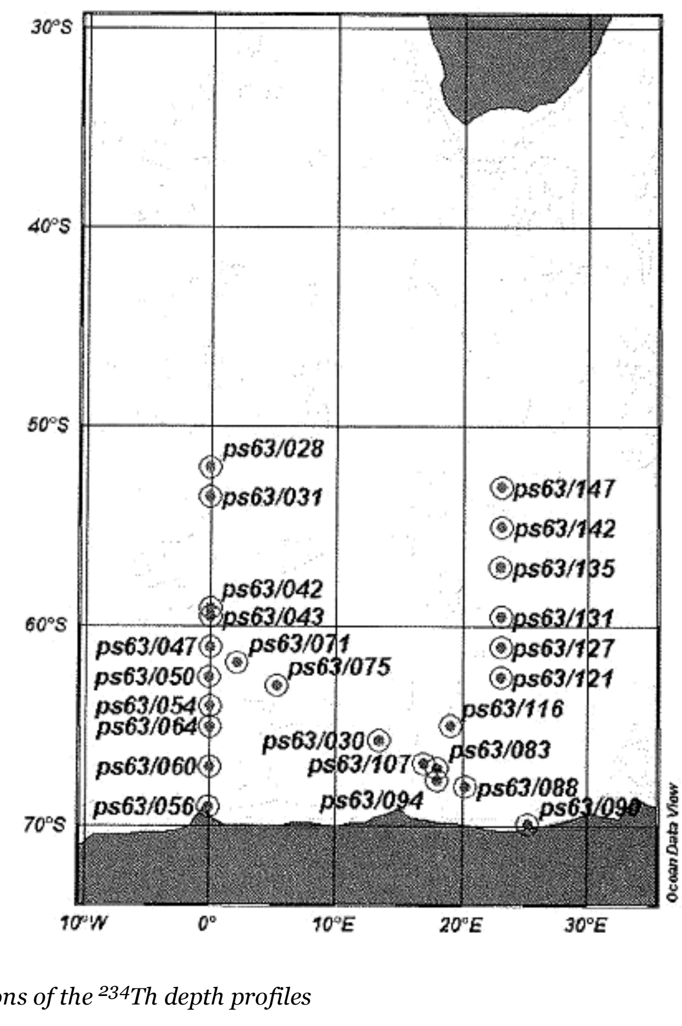

Figure 2.11-12: *Locations of the ^{234}Th depth profiles*

Oxygen

Samples for oxygen analysis were the first to be drawn from the Niskin bottle unless chlorofluorocarbon (CFC) samples were taken. Volume calibrated glass bottles of ~120 mL were used. A piece of Tygon tube was attached to the outlet tap of the Niskin bottle to allow the water to enter the sample bottle with minimum air contact and turbulence. The sample was allowed to overflow up to three times the bottle volume and the temperature of the seawater was then measured. The oxygen was chemically fixed and the bottles were capped and shaken. Samples were analyzed using the standard Winkler method [Grasshoff and Ehrhardt, 1983] within 12 h of collection. Whole bottle titrationswere performed as recommended forWOCE [Culberson, 1994]. The titration process was automated and the endpoint calculated using an electronic burette and photometer linked to a computer (SiS GmbH Dissolved Oxygen Analyzer). Duplicate samples were drawn and analyzed for 10% of all the samples. The analytical precision of these duplicates was 0.45%.

Nutrients

Polyethylene (PE) 50 mL bottles were used to collect subsamples from Niskin bottles for nutrient analysis. The PE bottles were rinsed three times with the sample water. The samples were poisoned with 105 mg/mL mercuric chloride (HgCl2), stored at 4°C and analyzed at the home laboratory 7 months after sampling. This preservation method has been shown to be successful for the storage of nutrient samples for up to 2 years [Kattner, 1999]. A Technicon autoanalyser II was used to measure the concentrations of Si, NO_x^-, NO_2^- and NH_4^+ using standard techniques [Grasshoff and Ehrhardt, 1983]. All the samples were analyzed in duplicate and the average difference of the duplicates from the mean was 0.23% for NO_3^- and 0.26% for Si.

Temperature and salinity

Temperature and salinity were recorded with a Seabird SEACAT SBE 19 instrument. Here, we report 5 m averages. Bottle data were related to the salinity and temperature of the nearest 5 m data point. A comparison of the physical data with that from another CTD instrument, which was operated in parallel and continuously calibrated against seawater standards (M. Schröder et al., The structure of the eastern Weddell Sea warm inflow, manuscript in preparation, 2010) yielded excellent agreement.

Surface sediment samples

From selected samples of the sediment surface, ^{230}Th activities will be determined in the near future in order to obtain sediment accumulation rates that may be compared with production data from the overlying water column. For locations of the sediment samples, see the respective chapters in this cruise report.

Preliminary conclusions

The obtained dataset gives for the first time a comprehensive insight into the production patterns of the eastern Weddell Gyre. The preliminary results fully support the starting hypothesis of a hitherto overlooked high productivity region in the Southern Ocean.

References

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2.12 Virioplankton abundance and bacteriophage of oligotrophic bacteria from polar seas

Jifang Yang and Timo Hagemann

Viruses are now considered to be an important component of aquatic microbial communities. The re-evaluation of the role of viruses in marine ecosystem is due to the discovery of high numbers of viruses and their abundances, typically numbering ten billions per litre. They probably infect all organisms, undergo rapid decay and replenishment and influence many biogeochemical and ecological processes, including nutrient cycling, respiration system, particle-size distributions and sinking rates, bacterial and algal biodiversity and species distributions, algal bloom control, dimethyl sulphide formation and genetic transfer. The marine bacterial community is responsible for a considerable portion of primary production and regeneration of nutrients in the microbial loop and is associated with a great variety of marine bacteriophages. The phages are parts of the marine virioplankton community and are capable of infecting a large portion of the bacterioplankton. It is assumed that, as part of the marine food web, bacteriophages play important quantitative and qualitative roles in controlling marine bacterial populations.

Oligotrophic bacteria have been defined as organisms with the capability to grow on a medium containing 1 mg or less than 1 mg of organic carbon per liter and have been found as the dominant populations in the Pacific Ocean and the polar seas. Occurrence and distribution of oligotrophic bacteria in Antarctic and Arctic seas were investigated and a few hundred of oligotrophic strains were isolated. Although there are a lot of reports about bacteriophages of marine heterotrophic bacteria, no reports of bacteriophages infecting marine oligotrophic bacteria are available. Investigating virioplankton abundance and bacteriophages of oligotrophic bacteria in polar seas are very important for better understanding the interactions between phages and their host organisms and the role of viruses in the polar marine ecosystem.

As part of an international cooperation between the AWI and SIO (Second Institute of Oceanography, China) this research cruise served to sample sea water and concentrate virus solution on board.

Work at sea

At ten stations in the Weddell Sea, seawater samples of about 200 liters were taken with a CTD-Rosette. The normal sample depths were 25 m and at two stations we took an additional sample of 400 m water depth. After separating algae and bacteria cells with a 0.2 µm / 0.45 µm Sartobran Capsule, the bacteriophages and viruses were concentrated thousandfold by tangential-flow-ultrafiltration using three Polyethersulfone Ultrasart Cassettes (0.1 m^2 effective filtration area each; 100 kdalton cut off). Twelve host bacteria strains, belonging to the alpha or gamma subclass of proteobacteria or the Cytophaga-Flavobaoterium-Bacteroides group, were infected each with 0.1 ml of the concentrated virus solution and incubated at 8°C to determine the bacteriophage concentration in seawater by counting the number of plaques on the plates. Meanwhile, about three litres seawater sample in every sampling station were filtered through a glasfibre filter for POC/PON measurement. This POC/PON measurement will be done in home laboratory.

Preliminary results

At each station a 200 ml bottle was filled with sample of the concentrated virus solution (Table 2.12-1). The twelve bottles were collected and stored at 4°C for further studies in home laboratory (morphology observation and DNA sequence analysis of virus). Preliminary results from plaque assay test confirmed the existence of oligobacteriophages in Antarctic Sea (Figure 2.12-1). There were high emergence rates relatively of phage plaque against host strain ARK126 (25%) or ANT43 (37%).

Table 2.12-1: *Sampling stations*

Sample No	Station No	Depth	Total plaques		Sample No	Station No	Depth	Total plaques
1	PS63/038-1	25 m	28		7	PS63/076-1	25 m	4
2	PS63/042-5	400 m	0		8	PS63/081-1	25 m	3
3	PS63/042-7	25 m	3		9	PS63/081-4	400 m	3
4	PS63/047-3	25 m	7		10	PS63/107-1	25 m	7
5	PS63/054-3	25 m	2		11	PS63/120-1	25 m	3
6	PS63/061-2	25 m	4		12	PS63/123-1	25 m	3

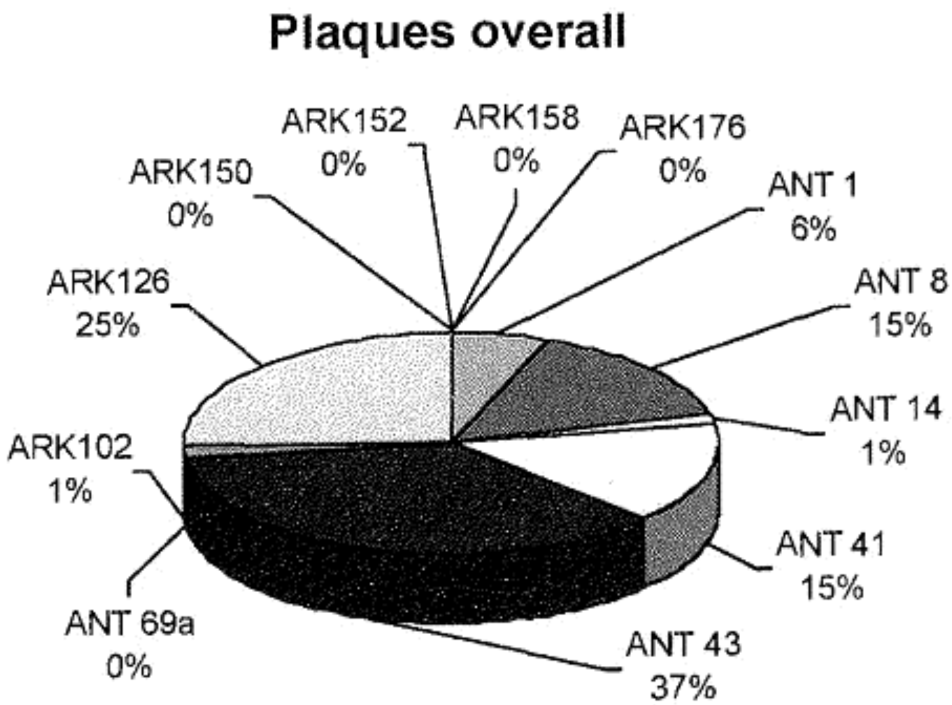

Figure 2.12-1: *Total number of occurred plaques*

No phage plaque against host strain ARK150 or ARK152 or ARM58 or ARK176 occurred

Acknowledgements

Especially, we want to thank technical assistant Mrs. Susanne Spahic who was involved deeply in preparations for the cruise expedition. This international cooperation project between the Alfred Wegener Institute and the Second Institute of Oceanography, 99 PR China, (CHN 01/034) was supported by the German Federal Ministry of Education and Research (BMBF).

Addendum of ANT-XIX/4

2.13 Community structure and abundance of oligotrophic bacteria

T.-L. Tan, S. Spahic', C. Germer

Objectives

Although not integrated in the ANDEEP projects, the aim of our participation is to study the abundance and diversity of oligotrophic, low-nutrient bacteria in south polar seas by using conventional and molecular biological methods. The results will be compared with the results of a similar expedition programme to the north polar region from June to August 2002 (ARK XVIII / la+b).

Work on board

For the above purpose, we have taken water samples at 10 stations from four depths (25, 100, 200, and 400 m). The water sampler (Rosette) was combined with CTD measurements (conductivity-temperature-salinity) in the water column (Table 2.13-1).

Table 2.13-1: *Salinity (psu) and temperature (°c) at the bacteriological stations*

Internal no.	PS no.	Date	Sal.Min.	Sal.Max.	Temp.Miri.	Temp.Max.
Bac St 01	61/130-2	03.03.2002	33.842	34.689	-0.18	2.547
Bac St 02	61/131-5	05.03.2002	33.374	34.675	-1.734	0.668
Bac St 03	61/133-2	07.03.2002	34.062	34.674	-1.713	0.601
Bac St 04	61/134-2	08.03.2002	32.845	34.684	-1.554	0.545
Bac St 05	61/135-2	10.03.2002	34.044	34.679	-1.544	0.531
Bac St 06	61/136-2	12.03.2002	34.11	35.662	-1.322	0.963
Bac St 07	61/137-2	14.03.2002	34.004	34.674	-1.218	0.773
Bac St 08	61/138-1	16.03.2002	33.223	35.617	-1.283	0.508
Bac St 09	61/139-2	19.03.2002	33.8812	34.6908	-0.6876	1.932
Bac St 10	61/141-1	22.03.2002	33.8823	34.6711	-1.1257	1.0599

The seawater samples have to be filtered for fluorescence *in situ* hybridizations (FISH) of the bacteria cells with phylogenetic specific oligonucleotide probes. Unfortunately, the stainless steel 10-fold filtration apparatus for FISH did not work smoothly for getting the amounts of filters needed, because the teflon sealing in the apparatus was damaged. Therefore, we could not get enough bacterial biomass to inspect ten different phylogenetic groups, as planned before.

Enrichment cultures in dialysis chambers and in Erlenmeyer-flasks with screw-on caps were kept at 4°C for further attempts to enumerate and isolate oligotrophic bacteria in the home laboratory.

Bacterial biomass for clone libraries from 25 and 400 m water depths has to be collected from 50 litres of seawater by means of a tangential flow microfiltration apparatus. However, the tangential flow filtration device did not function satisfactorily, because the disired high speed for the seawater flow of 4 litres per minute with the peristaltic pump was not reached with the Marprene tube delivered by the manufacturer. Silicone tubing was needed to get the high speed necessary for cell concentrations. Bacterial biomass was therefore concentrated on Millipore GP50 filters.

Seawater samples were also prepared in glass ampoules for dissolved organic carbon (DOC) and particulate organic carbon / particulate organic nitrogen (POC / PON) determinations on glass-fibre filters.

All preparations of seawater samples were kept frozen at -30°C.

Note

We got surface sediment samples to determine bacterial biomass from the stations 139-4, 139-8, 140-3, 142-4 and 142-5. The results will be of interest for the meiofauna working groups.

3. Annex

The achievements during the cruise were to a large extent due to the effective and friendly cooperation between the ship's crew and the participating scientific personal.

3.1 Beteiligte Institute/ Participating Institutes ANT-XX/1-2

Acronym	Adresse	Teilnehmerzahl
Deutschland		
AWI	Alfred-Wegener-Institut für Polar- und Meeresforschung Columbusstraße 27558 Bremerhaven	38
BFN	Bundesamt für Naturschutz INA - Insel Vilm 18581 Putbus	1
BIA	Berufsgenossenschaftliches Institut für Arbeitssicherheit Mirecourtstr. 9 53225 Bonn	1
DWD	Deutscher Wetterdienst Geschäftsfeld Seeschifffahrt Jenfelder Allee 70 A 22043 Hamburg	6
DSMZ	Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH Mascheroder Weg 1b 38124 Braunschweig	1

FIELAX	FIELAX Gesellschaft für wissenschaftliche Datenverarbeitung mbH Schifferstraße 10-14, 27558 Bremerhaven	3
GL	Germanischer Lloyd AG Vorsetzen 32/35 20459 Hamburg	3
GKSS	GKSS Forschungszentrum Institut für Küstenforschung Max-Planck-Straße 21502 Geesthacht	2
HSW	Helicopter Service Wasserthal GmbH Flughafen Hamburg Geschäftsfliegerzentrum, Geb. 347 22335 Hamburg	4
IMPG	Institut für Mineralogie Petrologie und Geochemie der Universität München Theresienstraße 41/III 80333 München	1
ISITEC	ISITEC GmbH Stresemannstr. 46 27570 Bremerhaven	1
IUPB	Universität Bremen Institut für Umweltphysik Otto-Hahn-Allee 1 28359 Bremen	5
IUPH	Universität Heidelberg Institut für Umweltphysik Im Neuenheimer Feld 229 69120 Heidelberg	3
LAEISZ	Reederei F. Laeisz Barkhausen-Str. 37 27568 Bremerhaven	1
OPTIMARE	Optimare Sensorsysteme AG Coloradostraße 5 27580 Bremerhaven	1

See-BG	Seeberufsgenossenschaft Reimerstwiete 2 20457 Hamburg	1
WERUM	Werum Software & Systems AG Wulf-Werum-Str. 3 21337 Lüneburg	1
China		
SOA	Second Institute of Oceanography PO Box 1207 Hangzhou P. R. China	1
Frankreich		
GENAVIR	GENAVIR Zone portuaire de Bregallion B.P. 330 83507 La Seyne-sur-mer cedex	
IFREMER	IFREMER Centre do Toulon Zone portuaire de Bregallion B. P. 330 83507 La Seyne-sur-mer cedex	2
OCEANO	OCEANO Technologies Rue Rivoalon, Sainte-Anne du Portzic 29200 Brest	1
Großbritannien		
CER	Centre of Environmental Risk University of East Anglia Norwich NR4 7TJ	1
CHYORK	University of York Dept. of Chemistry York, YOlO 5DD	2
lENS	Lancaster University Environmental Science Lancaster, LA1 4YQ	1
UMIST	University of Manchester Institute of Science and Technology PO Box 88 Manchester M6O 1QD	1

Norwegen

LIT	Universitetet i Tromsø Institutt for Geologi Dramsveien 201 9037 Tromsø	1

Südafrika

UTC	University of Cape Town Dept. of Oceanography Rondebosch 7701 Cape Town	4

3.2 Wissenschaftliches Personal / Scientific crew

Name		Institut	ANT-XX/1	ANT-XX/2
Ansorge	Isabelle Jane	UTC		X
Baier	Uli	FIELAX	X	
Bakker	Dorothee	CER		X
Belier	Frederic	OCEANO	X	
Bluszcz	Thaddus	AWI	X	
Boebel	Olaf	AWI		X
Brückner	Sylvia	AWI		X
Büchner	Jürgen	HSW		X
Buldt	Klaus	DWD	X	
Caba	Armando	GKSS	X	
Deckelmann	Holger	AWI	X	
Didié	Claudia	AWI		X
Dinter	Wolfgang	BFN		X
Durham	Louise	ENS	X	
El Naggar	Saad	AWI	X	
Forwick	Matthias	UIT		X
Fütterer	Dieter Karl	AWI		X
Geibert	Walter	AWI		X
Gerchow	Peter	FIELAX	X	
Giljam	Rhys Thomas	UTC		X
Graeser	Jürgen	AWI	X	X
Graeve	Martin	AWI	X	
Hagemann	Timo	AWI		X
Halasia	Magdalini A.	UPH		X
Hanfland	Claudia	AWI		X
Hass	Christian	AWI		X
Heckmann	Hans-Hilmar	HSW		X
Hemmerling	Börge	UPH	X	
Hoppema	Jan Marinus	UEB		X
Jaeneke	Matthias	DWD	X	

Name		Institut	ANT-XX/1	ANT-XX/2
Kattner	Gerhard	AWI	X	
Klatt	Olaf	AWI		X
Kleffel	Guido	AWI		X
Knuth	Edmund	DWD		X
Krischat	Joachim	AWI		X
Kuhn	Gerhard	AWI		X
Lakaschus	Sönke	GKSS	X	
Lehnberg	Barbara	DSMZ	X	
Lensch	Norbert	AWI		X
Max	Thomas	AWI	X	
Menßen	Jens	HSW		X
Mizdalski	Elke	AWI	X	
Monsees	Matthias	AWI		X
Müller	Eugen	DWD	X	
Niederjasper	Frederic	AWI	X	
Niehoff	Barbara	AWI	X	
NN		AWI	X	
NN		GL	X	
NN		GL	X	
NN		GL	X	
NN		IFREMER	X	
NN		IFREMER	X	
Nunez	Ismael	AWI		X
Pols	Hans-Arnold	DWD		X
Reinke	Manfred	AWI	X	
Rohardt	Gerd	AWI		X
Rohr	Harald	OPTIMARE		X
Sablotny	Burkhard	AWI	X	
Sander	Hendrik	IUPB		X
Schattenhofer	Martha	IUPB		X
Schiel	Sigrid	AWI	X	
Schmidt	Thomas	FIELAX		X
Schmitt	Wolfgang	IMPG		X
Schröder	Michael	AWI		X
Schulz	Astrid	AWI	X	
Seidler	Kai	HSW		X
Thomalla	Sandy	UTC		X
Usbeck	Regina	FIELAX		X
Vöge	Ingrid	AWI		X
Wagner	Eberhard	LAEISZ	X	
Wahl	Sebastian	AWI		X
Waldthausen, v.	Constanze	AWI		X
Webb	Adrian Myles	UTC		X
Wevill	David	CHYORK	X	X
Williams	Paul Ivor	UMIST	X	
Wittling	Thomas	AWI		X
Yang	Jifang	SOA		X

3.3 Schiffspersonal / Ship's crew

Rank	Name		ANT-XX/1	ANT-XX/2
Master	Domke	Udo	X	X
1.Offc.	Spielke	Stefan	X	
1 Offc.	Schwarze	Stefan		X
Ch. Eng	Pluder	Andreas	X	X
2 Offc.	Spielke	Stefan		X
2. Offc.	Szepanski	Nico	X	X
2. Offc.	Thieme	Wolfgang	X	X
R. Offc.	Koch	Georg	X	X
Doctor	Böttcher	Herbert		X
1. Eng.	Delif	Wolfgang	X	X
2. Eng.	Ziemann	Olaf	X	X
3. Eng.	Zornow	Martin	X	X
Electr.	Muhle	Heiko	X	X
Boatsw.	Clasen	Burkhard	X	X
Carpenter	Reise	Lutz	X	X
AB	Gil glesias	Luis	X	X
AB	Pousada Martinez	S.	X	X
AB	Kreis	Reinhard	X	X
AB	Schulz	Ottmar	X	X
AB	Burzan	G.-Ekkehard	X	X
AB	Moser	Siegfried	X	X
AB	NN		X	X
AB	Hartwig	Andreas	X	X
Storek	Preußner	Jörg	X	X
Mot-man	Ipsen	Michael	X	X
Mot-man	Voy	Bernd	X	X
Mot-man	Elsner	Klaus	X	X
Mot-man	Hartmann	Ernst-Uwe	X	X
Mot-man	Grafe	Jens	X	X
Cook	Haubold	Wolfgang	X	X
Cookmate	Völske	Thomas	X	X
Cookmate	Silinski	Frank	X	X
1. Stwdess	Jürgens	Monika	X	X
Stwdss/KS	Wöckener	Martina	X	X
2. Stwdess	Czyborra	Bärbel	X	X
2. Stwdess	Silinski	Carmen	X	X
2. Steward	Gaude	Hans-Jürgen	X	X
2. Steward	Möller	Wolfgang	X	X
2. Steward	Huang	Wu-Mei	X	X
Laundrym.	Yu Kwok	Yuen	X	X

CCHDO Data Processing Notes

Date	Person	Date Type	Event	Summary
2004-02-17	*Witte, Hannelore*	CTD/SUM	Submitted	1999a, 2000a, 2002a Data Submitted Together

This is information regarding line: A12
ExpoCode: 06ANTXVI_2, ANTXVIII_3, ANTXX_2
Cruise Date: 1999/01/18 - 2003/01/15
From: WITTE, HANNELORE
Email address: hwitte@awi-bremerhaven.de
Institution: AWI
Country: GERMANY

The file: AWICTD.tar - 4248576 bytes has been saved as: 20040217.052429_WITTE_A12_AWICTD.tar in the directory: 20040217.052429_WITTE_A12

The data disposition is:

- Public

The file format is:

- WHP Exchange

The archive type is:

- Other: Tar/Zip/Tar

The data type(s) is:

- Summary (navigation)

CTD File(s)

The file contains these water sample identifiers:

- Cast Number (CASTNO)
- Station Number (STATNO)

WITTE, HANNELORE would like the following action(s) taken on the data:

- Merge Data

Date	Person	Date Type	Event	Summary
2004-04-13	*Bartolacci, Danie*	SUM	Website Update	

Notes on sumfile reformatting:
2004.04.13 DMB
I have reformatted the A12_2002a sumfile:

- Changed expocode from 06ANTXX_2 to 06AQ200211_2
- Changed date format from yyyymmdd to mmddyy
- Added event code as UN
- Changed position format from DD.dd to DD MM.mm
- Added hemisphere alphabetic
- Added NAV as UNK
- Realigned all columns to conform with WOCE standards
- Added name/date stamp
- Ran sumchk with no errors

file was renamed a12_2002asu.txt and put online.

Date	Person	Date Type	Event	Summary
2004-04-15	*Bartolacci, Danie*	CTD/SUM	To go online	EXCHANGE Format, No Qual Values

CTD files are in .csv format, but at present have no quality bytes associated with values and therefore cannot be converted to netCDF at this time.

A directory and web page files have been created for this cruise. All station track and data files link. This cruise will not link to the website until web-generating code is working and run.

Notes on sumfile reformatting:
2004.04.13 DMB
I have reformatted the A12_2002a sumfile:

- Changed expocode from 06ANTXX_2 to 06AQ200211_2
- Changed date format from yyyymmdd to mmddyy
- Added event code as UN
- Changed position format from DD.dd to DD MM.mm
- Added hemisphere alphabetic
- Added NAV as UNK
- Realigned all columns to conform with WOCE standards
- Added name/date stamp
- Ran sumchk with no errors

file was renamed a12_2002asu.txt and put online.

Date	Person	Date Type	Event	Summary
2004-04-20	*Bartolacci, Danie*	CTD	Website Update	

- Added quality bytes for all values (2 if valid value was present, -999. if value was missing) and associated comment lines in header.
- Added CTDOXY and flag column with missing values and missing value flag. This was done in order to convert files into netcdf (our in-house code requires all columns be present).
- Renamed all station files to CCHDO format.
- Converted files to netcdf with no apparent errors.